Environment Canada
Environnement Canada

Brief to the Nova Scotia Royal Commission on Forestry

Volume 1: Departmental Overview
Canadian Forestry Service

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This is the first volume of two in the Environment Canada Brief to the Nova Scotia Royal Commission on Forestry. It contains two sections:

SECTION 1: DEPARTMENTAL INTRODUCTION
SECTION 2: CANADIAN FORESTRY SERVICE

Volume II of this brief contains the submissions prepared by Parks Canada, Canadian Wildlife Service and the Environmental Protection Service.

INTRODUCTION

ENVIRONMENT CANADA

BRIEF TO THE NOVA SCOTIA ROYAL COMMISSION ON FORESTRY

MARCH, 1983

Introduction

This brief is presented by the Regional Director General of Environment Canada (Atlantic Region) on behalf of the Department. It consists of an introduction followed by briefs from the following Services: Canadian Forestry Service (CFS); Parks Canada; Canadian Wildlife Service (CWS); and Environmental Protection Service (EPS).

Environment Canada was created by the Government Organization Act Part I (1970) and Part III (1979). Its purpose is to foster harmony between society and the environment for the benefit of present and future generations of Canadians.

The natural environment both shapes and is shaped by human activity, and touches upon all aspects of life. Its biophysical systems, such as the forests of Nova Scotia, provide life support and habitation for humans and other living organisms. It provides basic natural resources to support human needs, and it in turn receives, or is affected by, the products of human activity. It is also a source of beauty, aesthetic delight and spiritual renewal. The natural environment is the heritage of all, and is held as a commons - it belongs to everyone, yet is the exclusive property of no one.

Seen in this light, Environment Canada activities and interests with regard to the forests in Nova Scotia are:

(1) to promote the sustained use of Nova Scotia forests for the economic, social and aesthetic benefits of present and future generations. This is accomplished primarily by conducting research in the development of and maintenance of the forest resources, working with the Province, in addition to joint activities with the Province and providing assistance to woodlot owners.

(2) to contribute to the achievement and maintenance of a state of the environment that is necessary to the health and well-being of man as

well as the health and diversity of species and ecosystems. The Department contributes scientific and technical advice on forest management practices and their effects on the environment. It also monitors and evaluates changes in the environment due to such practices, and where federally managed natural resources are at risk, takes the necessary actions to protect them.

(3) to provide information on related natural phenomena such as weather, climate and water enabling man to adapt his forest management activities appropriately.

(4) to protect significant examples of natural and cultural heritage, as for example in the establishment of national and historic parks, many of which contain significant forested areas.

Environment Canada recognizes the critical importance of the forests of Nova Scotia, both as the resource base for the forest industry and as a basic part of the Nova Scotia environment. Because forests cover three quarters of the Province, what happens to forests dictates much of what happens to the environment of the Province and to living things therein, including people. Similarly, because the forest based industry accounts for as much as thirty percent of provincial exports, it is crucial that the forest resource be well managed. The Environment Canada brief is therefore directed toward providing to the Commission information and advice, intended to assist in (1) the management of the forest resource for the benefit of the greatest number of users, and (2) the environmentally acceptable conduct of forest management activities.

Forests are a provincially managed and a largely privately owned resource in Nova Scotia. The federal government's interests in forestry relate to forest research, forest products research, maintenance of employment, the social costs of unemployment, international trade and the balance of foreign exchange, federal revenues, impacts of federal policies on taxation and transportation relative to the forest industry, and management of federal lands. There are federal interests related to the practice of forestry such as the protection of humans, birds, fish and other components of the biosphere. The federal Department of Agriculture is responsible for the general registration of pesticides and their use characteristics in Canada. The approval of specific permits for the application of pesticides is the responsibility of the provincial government. Detrimental effects of pesticides on components of the environment can be pursued legally by both levels of government.

Somewhat more specifically:

The Canadian Forestry Service program in Nova Scotia is directed toward the solution of major forestry problems and the development of more effective forest management techniques. Current research and development activities include silviculture, forest pest management, tree growth and nutrition, and the impacts of forestry practices on the environment. A technical and information services program provides responses to requests for assistance from the forestry sector. The Canadian Forestry Service operates an office in Truro for implementing Intensive Forest Management (IFM) through the Canada/Nova Scotia Forestry Agreement. This office, a unit of the Maritimes Forest Research Centre, is also responsible for liaison with the government, industry and public in Nova Scotia.

The brief from this Service focuses on the need for intensive forest management (IFM) in Nova Scotia in order to maintain a wood supply for the existing industrial base through the year 2000 and beyond. Techniques involved in the IFM system deal with the wood production cycle from planting through maintenance to harvesting. The CFS brief deals with the problems either real or perceived that the IFM system must contend with. Among the problems identified by CFS is the current distortion of the forest age structure (three quarters of Nova Scotia forest trees are over 40 years old), land ownership (73% is privately owned), an imbalance in the softwood available (a shortage in eastern Nova Scotia, a surplus in the west), and public opposition to certain forest management practices such as chemical spraying, single species plantations, and clearcutting. Details of this brief will be presented later by the CFS representative.

Parks Canada is that Service of Environment Canada entrusted with responsibility to protect those places which are significant examples of Canada's natural and cultural heritage. The primary responsibility is to conserve, protect and interpret the resources, including natural and historic resources, wildlife, flora, geological features and artifacts. Two Parks Canada properties in Nova Scotia have large land bases. Together, Cape Breton Highlands National Park and Kejimkujik National Park occupy 2.5 percent of the Province's land area. Management of the park land is directed toward protecting the natural heritage by maintaining the environment in as natural a state as possible. Dedication of park land to this form of management has benefits to the forest industry as natural laboratories where ecological processes can be studied or as areas where genetic diversity of biological resources is maintained.

The Parks Canada brief describes how two blocks of largely forested land in Nova Scotia are being managed for a different kind of use. The benefits of the national parks are described with reference to their relationship to other forest lands of Nova Scotia. Because of the nature of and the use of these parks, it is pointed out that special considerations are needed in the management of those forest lands immediately adjacent to parks. National parks also act as potential reservoirs for genetic materials that may otherwise have disappeared; the role of parks as areas for forestry related research is also specified. The use to which the forests of the national parks will be put in the future is indicated.

The Canadian Wildlife Service administers the Migratory Birds Convention Act (1917) and regulations, in cooperation with provincial governments. CWS also has legislated responsibilities under the Canada Wildlife Act of 1973. Under provisions of these Acts the Service discharges research and regulatory obligations, including management and protection of migratory birds, preservation of wetland habitat, rare and endangered species, and wildlife populations shared with other provinces or countries. The Service conducts studies for and advises Parks Canada, and conducts research relative to environmental contaminants. The forests of Nova Scotia have particular relevance as habitat for wildlife species and certain techniques used in forest management are relevant to the Service in its role as a wildlife manager.

In the Canadian Wildlife Service brief a number of the relationships between wildlife and their forest habitats are discussed. The benefits and disbenefits of certain forest management practices to wildlife habitat are considered. In particular, methods of forest harvesting such as clearcutting and methods of reforestation involving conifer plantations pose problems. CWS also points out some of the hazards associated with chemical sprays and provides advice and information on their use, the details of which a CWS representative will present later.

The Environmental Protection Service is responsible for ensuring that, to the extent that the federal government has influence or authority, human activities are conducted in a way that will achieve and maintain a state of the environment necessary for the health and well-being of man, the health and diversity of ecosystems, and the sustained use of natural resources for social and economic benefit. This objective gives EPS a perspective of the forest in which a balance must be found between the long term health of the forest industry and the long term uses of the forest.

Three of the activities of EPS are of particular relevance to the Commission:

(1) Advising on matters pertaining to environmental quality.

(2) Protecting the environment from the potentially harmful effects of chemicals used in forest protection and management.

(3) Encouraging and supporting efforts by government, business, industry and labour to adopt environmentally responsible practices.

The brief prepared by EPS deals with the impacts upon the environment of forestry practices and with the use of chemical sprays in forest management. For example, misuse of some harvesting methods, or reforestation practices, can lead to loss of valuable forest soil and excessive sedimentation in streams. Hazards which may be associated with tree farming relating to infestations, soil acidification and ecosystem diversity are discussed. With regard to chemical sprays, the insecticides currently in use for forestry have not been found to create long term, adverse environmental impacts. For herbicides, observations of the natural environment have not revealed changes that can be measured that are large enough to exceed normal temporal variations. Nonetheless, a number of cautionary recommendations are provided that could help to ensure the safest possible use of chemical sprays. These points will be given in more detail by a representative of EPS.

The forests of Nova Scotia belong to many shareholders - the private citizen, the interest groups, the Crown, the industries, the general public - each with their own set of unique interests. It is understandable that these interests are not always compatible, and indeed may sometimes be in direct conflict. Our objective in this brief is to assist the Commissioners to develop the management perspective that integrates long term growth and environmental considerations, for sound forestry management and good environmental practice go hand in hand. A balanced approach based on best available scientific and social values must therefore emerge if the forests of Nova Scotia are to continue to serve the

the greatest number of shareholders. This brings back the point raised at least twice in the Environment Canada briefs, that being the need to involve a wider spectrum of "interest holders" in the planning and designing of forest management programs.

The Environment Canada Service briefs, to be presented in greater detail by a representative of each Service are contained in these 2 volumes in the following order:

Canadian Forestry Service
Parks Canada
Canadian Wildlife Service
Environmental Protection Service.

FOREST MANAGEMENT
IN NOVA SCOTIA

A Brief Presented To
The Royal Commission on Forestry
in Nova Scotia

by

The Canadian Forestry Service

Maritimes Forest Research Centre

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1

2.0 IMPORTANCE OF FORESTRY TO NOVA SCOTIA 3

3.0 THE FOREST RESOURCE 4

- 3.1 Ownership 4
- 3.2 Wood Supply and Demand 5
- 3.3 Current Efforts to Combat Shortfall 6
  - 3.3.1 Intensive Forest Management Strategies 6
  - 3.3.2 Constraints 7
  - 3.3.3 Current and Future Efforts to Alleviate the Shortfall in Wood Supply 8
    - 3.3.3.1 Land Tenure 8
    - 3.3.3.2 Imbalanced Wood Supply 9
    - 3.3.3.3 Forest Protection 10

4.0 PUBLIC REACTION TO INTENSIVE FOREST MANAGEMENT 11

- 4.1 Intensive Forest Management - A Definition 12
- 4.2 Public Perception and Intensive Forest Management 13
  - 4.2.1 Selection-cutting, Highgrading and Clear-cutting 13
  - 4.2.2 Site Preparation 15
  - 4.2.3 Plantations 17
  - 4.2.4 Herbicides 18
  - 4.2.5 Insecticides 19
  - 4.2.6 Fertilizers 24
  - 4.2.7 Genetics 25
  - 4.2.8 Forest Utilization 26
- 4.3 Current and Future Efforts to Respond to Public Concerns Regarding Intensive Management Techniques 27
  - 4.3.1 Pesticides and Herbicides 27
  - 4.3.2 Other Intensive Forest Practices 28
  - 4.3.3 Forest Utilization 29

5.0 PUBLIC INFORMATION 30

6.0 ROLE OF RESEARCH AND DEVELOPMENT IN THE IMPROVEMENT OF FOREST MANAGEMENT TECHNIQUES 32

7.0 EXTENSION 34

8.0 ACID RAIN 37

9.0 RECOMMENDATIONS 39

10.0 BIBLIOGRAPHY OF SELECTED SUBJECTS 42
10.1 Acid Rain 42
10.2 Pesticides 43
10.3 Spruce Budworm Wood Losses 44
10.4 Spacing and Thinning 44
10.5 Fertilizers 48

11.0 APPENDICES OF DATA RELATING TO FOREST ECONOMICS, WOOD SUPPLY, HERBICIDES, AND LOSSES TO THE FOREST RESOURCE FROM FOREST INSECTS AND DISEASES 49

1.0 INTRODUCTION

Over one million Canadians are employed directly or indirectly in the forest industry. Sales of Canadian forest products totalled $24 billion in 1981, of which $13 billion were export sales. This provided a positive balance of exports of $11.4 billion. Signs that the resource that supports this vital industry is in trouble are abundant and frightening. Until the past decade, our approach to forest management has been almost exclusively one of exploitation, and the resource base has been allowed to degenerate to the point where the industry is facing economic stagnation. At the present time almost one-eighth of Canada's productive forest area can be classified only as silvicultural slum - unable to produce a merchantable crop within the next sixty to eighty years. Even today 200 000 to 400 000 hectares (ha) are being added annually to this slum. Most of Canada's high quality forest has been harvested and local wood shortages have developed in every Province. While Nova Scotia may have its own unique forestry problems, this generally bleak picture applies as much to this Province as it does anywhere in Canada.

Fortunately, Nova Scotia, like all other jurisdictions across Canada, has recognized that sound intensive management, including the tending of existing forests and the creation of new ones, can provide the solution to most of its forestry problems. As a result, Nova Scotia, with federal assistance, has embarked on large-scale programs of forest renewal.

Nova Scotia's current forestry objectives are - to encourage and support forest management to increase the sustainable supply of softwoods to an average of 3.3 million m3 annually, thus ensuring the continued viability and competitiveness of the present wood-based industry; and to improve and increase the utilization of the forest to enhance future forest industry development opportunities.

The Canadian Forestry Service agrees with these objectives and wholeheartedly supports their attainment as a valid and essential contribution to forestry in Nova Scotia as well as to national forestry objectives. Further, we fully endorse the strategy that has been laid out to attain these objectives; indeed, we have been a party to its design.

In the following brief we have attempted, from a Canadian Forestry Service viewpoint, to identify and describe major problems and constraints that could mitigate against attainment of provincial forestry objectives. Where possible we have also suggested likely solutions.

We have not addressed in detail the important subject of the spruce budworm, because this subject has been reviewed completely in the 1980 Canadian Forestry Service brief to the Newfoundland and Labrador Royal Commission on Forest Protection and Management, which we are making available to you.

2.0 IMPORTANCE OF FORESTRY TO NOVA SCOTIA

Although there is almost continuous reference to mismanagement of Nova Scotia's forests, relatively little has been said of the benefits that have accrued from this so-called exploitation. The Province and its people have, in the past, derived great wealth from its forests and today forestry and related industries in Nova Scotia employ more than 6500 persons directly. Pulp and paper mills rank second and sawmills fourth in employment and wages paid in the manufacturing sector of the Province. The majority of this employment is in rural areas where jobs are scarce. In terms of value added, which includes wages and salaries, rent, taxes and other costs, pulp and paper mills rank first among manufacturing in the Province and sawmills sixth. Together they contribute about $180 million annually to the provincial economy. In all of Canada only British Columbia and New Brunswick rank ahead of Nova Scotia in terms of percent of value added from forestry compared to other goods producing sectors.

Annual value of output of sawmills and pulp and paper mills is roughly $330 million. An additional $170 million is provided by related industries such as shingle mills, box factories and paper converters. The majority of this output is exported. In recent years, this has amounted to about 30 percent of the value of all provincial exports. Income from these sales provides foreign exchange for the purchases of imported goods and services.

In short, forestry has played and will continue to play a vital role in Nova Scotia's social and economic well being, provided that long-term commitments are made to invest in, and practice intensive forest management.

3.0 THE FOREST RESOURCE

Nova Scotia comprises a land and water area of 5 500 000 ha (13.7 million acres) of which 4 100 000 ha (10.2 million acres) are forested. Approximately 92 percent or 3 772 000 ha (9.38 million acres) of the forested area is considered productive for the purpose of forest management.

The forests of the Province contain an estimated 280 000 000 m³ (Gross Merchantable Volume-all species) of which 69 percent is softwood. Of this 193 200 000 m³ softwood volume, 29 percent is of sawlog size and quality, 20 percent undersized sawlogs or studwood, 50 percent is suitable for pulpwood and 1 percent is cull. Of the 86 800 000 m³ of hardwood volume, 16 percent is of sawlog quality and size, 10 percent is classified as boltwood, 70 percent is suitable for pulpwood and 4 percent is cull.

Regionally, (assuming a division of the Province into western, central and eastern regions roughly equal in area), significant differences in product distribution occur. For instance, only 22 percent of the softwood sawlogs are in the eastern region. The remainder is divided almost equally between the central and western regions. Fully 41 percent of the pulpwood is in the eastern region compared to 37 percent in the central region and 22 percent in the western region.

The forest age classes are unbalanced, with 41 percent of the productive forest consisting of stands over 60 years old. An additional 35 percent is between 41 and 60 years old and the remaining 24 percent is immature. The current mean annual increment of mature softwood stands is 2.1 m³ per ha per year (30 cu ft per acre per year). This low increment is indicative of the mature and overmature nature of a large portion of the forest estate and the lack of management applied to it.

3.1 Ownership

Ownership of forest land is distributed among four broad classes of owners as follows: Provincial Crown, 24 percent; Federal Crown, 3 percent; large freeholds with more than 400 ha, 21 percent; and small freeholds with less than 400 ha, 52 percent. This tenure pattern resulted primarily from settlement of the Province by immigrants, disbanded troops, and Loyalists during and immediately following the American Revolution. As a result, Nova Scotia has the second highest proportion (73%) of private forest land ownership of all provinces in Canada. Only Prince Edward Island ranks higher (90%). For Canada as a whole, less than 10 percent of forest land is privately owned.

As might be expected from this settlement pattern, there is a large number of small woodland owners. Recent figures show that for the small freehold group there are an estimated 30 000 owners with an average ownership of 100 ha, yet these individuals own 52 percent of the total forest area. Of the gross merchantable volume, 22 percent is on Provincial Crown land, 3 percent is on Federal Crown land, and 75 percent is on private land.

3.2 Wood Supply and Demand

The forest industry in Nova Scotia utilizes approximately 3.4 million m3 of softwood annually. It is estimated that the sustainable annual harvest of softwoods without a program of intensive forest management is 2.4 million m3.

In western Nova Scotia there is a surplus of softwood while in the seven eastern counties there is a deficit. When Nova Scotia Forest Industries was established at Port Hawkesbury it was known that the available wood supply in the seven eastern counties was inadequate to keep the mill operating at full capacity. However, an elaborate forest management plan was put in place which would see the orderly utilization of mature softwood stands over the next 20 years, in conjunction with sivicultural programs to increase future fibre yield. If the plan were followed, it was expected that the wood supply would be just adequate. The uncontrolled spruce budworm outbreak in Nova Scotia during 1977-81 threw into disarray the orderly liquidation of the mature softwood stands and resulted in the loss of hundreds of hectares of young silviculturally improved forest which was to be the future wood supply for the mill. There is now no way to grow enough wood in the seven eastern counties to meet the expected shortfall by the year 2000. Wood will have to be imported from the central and western regions of the Province. The increased pressures on the resource in these regions will require greater expenditures on forest management activities, including protection. If these resources are also lost, then much of the industry will fail because there is no alternative source of softwood in Nova Scotia.

3.3 Current Efforts to Combat Shortfall

3.3.1 Intensive Forest Management Strategies

Current provincial efforts in intensive forest management are strongly supported by the Federal/Provincial Forest Management Agreements of 1977 and 1982. Under the present Agreement, the total area to be treated annually should be approximately 20 000 ha, of which 10 000 ha are to be planted and 10 000 ha either cleaned, thinned, or salvage cut on Crown and private lands. This represents approximately two-thirds of the annual cutover area.

The Province expects to have the capability to produce 30 million quality seedlings annually by 1984, enough to plant 10 000 ha per year, or one-third of the forest area being harvested. Through planting, yield per acre may be increased by up to 250 percent and the minimum age to harvest decreased by up to 50 percent. Further increases in yields of up to 15 percent may be achieved by using genetically improved seed. Increases of 30 percent can also accrue from mechanical site preparation. Spacing or cleaning suitable naturally regenerating stands may shorten the rotation age by upwards of 40 years for pulp, or 20 years for sawlogs. Including the wood obtained by thinnings, the total harvest over a 60-year rotation can be up to 200 percent higher than the expected yield from unmanaged stands.

Site preparation increased to 8 percent of the area harvested in 1979/80 from 2 percent in 1975/76. Similarly, the area planted increased from 6 percent of the area harvested in 1975/76 to 13 percent in 1979/80. Spacing became an accepted practice and the hectares treated per year have steadily increased. This level of management input might have been enough to sustain the industry but for the drastic loss of fibre to the spruce budworm, which commenced at about the same time and has continued to the present.

Forestry practices now in place through Federal/Provincial agreements should, barring greater than long-term average losses that could be expected from fire, insects, and diseases, assure a sustained annual yield of softwood of 3.3 million m3.

3.3.2 Constraints

Theoretically, the programs undertaken under the Canada/Nova Scotia Forestry Agreement are sound and objectives are realistic and attainable. However, there are four major constraints as follows:

1. Seventy-three percent of the Province's forest is in private hands, and over half of the forest land is in small holdings. The attainment of any long-term management objectives requires the tacit approval and active participation of a large proportion of land owners over whom the Province has little or no control.

2. In terms of attainment of forestry objectives, the Province can be divided into two parts; the seven eastern counties and the rest. The overcut in the eastern counties, due in large measure to budworm salvage operations, must eventually be compensated by wood from the remainder of the Province. However, small freeholds in the west may not be able to provide long-term security of supply, while owners of large freeholds may be unwilling to supply competitors. Long-distance transport of wood may be prohibitively expensive.

3. The spruce budworm epidemic persists, and spruce bark beetle damage is increasing and the gypsy moth has appeared in small numbers in the western end of the Province. These insects and other potential pests may take a larger-than-expected harvest of the forest resource and thereby render attainment of objectives impossible.

4. Finally a key factor affecting efforts to renew Nova Scotia forests is public apprehension concerning possible adverse effects of intensive forest management practices. Public concern has already temporarily restricted pesticide use and could generate other restrictions.

Public perception of intensive forest management techniques will be discussed in a later section of this Brief. Efforts concerning the problems of land tenure, imbalance of wood supply, and protection from pests are outlined below.

3.3.3 Current and Future Efforts to Alleviate the Shortfall in Wood Supply

3.3.3.1 Land Tenure

The Group Venture concept of the Forestry Agreements is designed to ease the problem of land tenure by bringing small individual lots into larger more efficient management units. There are now eight such management units involving over 600 woodlots.

The incentives program of the Agreement includes woodlots as small as 20 ha in size, and it is estimated that 8000 small landowners in the Province are both interested and eligible for financial and technical assistance under the Agreement.

The land tenure problem might also be partially alleviated by persuading small landowners to manage their forests more productively. To this end, the education program under the past agreement has provided a wealth of technical information, highlighted perhaps by the publication "The Trees Around Us" and the "Forest Times", which are of great assistance to the small woodlot owner. In addition, the Canadian Forestry Service has increased its activities in the area of technology transfer to small woodlot owners.

The problem of tenure can also be approached indirectly through research and development of new techniques to make woodlot management more profitable. Can new uses be found for woodlot by-products other than sawlogs, pulpwood, Christmas trees, and maple products? Can "affordable" technology, particularly in extraction equipment, replace expensive heavy machinery? A break-through in these areas would greatly increase the profitability of small woodlots and stimulate more interest in forest management.

A final alternative is for the Province to accelerate its land purchases to increase the proportion of Crown land. This would reduce the dependence on small woodlots. However, such actions would have unpredictable social effects and, coupled with land purchases by the existing pulp and paper companies, could change the character of substantial parts of rural Nova Scotia.

3.3.3.2 Imbalanced Wood Supply

The problem of wood distribution is very difficult. Because owners of large freeholds are not likely to assist their competitors, the answer to the problem must lie in the utilization of wood from small freeholds and Crown land. Between now and 2005, some mechanism must be put in place to redistribute wood from small freehold and Crown land to users in relation to their requirements and their available wood supply. A marketing cooperative or a wood supply brokerage operated by private woodlot owners associations in concert with the Department of Lands and Forests, might be able to regulate the flow of wood and reduce the effect of expected high transportation costs.

3.3.3.3 Forest Protection

The over all management plan for the forest resource as outlined in the Federal/Provincial Forestry Agreements does not envisage extensive losses caused by the spruce budworm, or other insect disease problems.

The Canadian Forestry Service has a mandate to (1) advise on forest pesticide usage, especially in the registration process under the pest Control Products Act; (2) conduct research in new products, formulations, and application techniques with a view to finding safer, more effective, and cheaper ways of protecting stands and of assisting forest renewal; (3) conduct research on environmental impacts of forest spray operations; (4) research a wide range of damage control techniques, including biological insecticides and other biological and silvicultural control methods; and (5) study management strategy design and the economics of pest impacts.

The Canadian Forestry Service evaluates spray strategies and tactics, and is heavily involved in spray research and technology. However, it is not directly involved in spray operations, nor does it register chemical pesticides or approve permits to spray. The decision to spray is the sole responsibility of the landowner (provincial governments and the private sector).

4.0 PUBLIC REACTION TO INTENSIVE FOREST MANAGEMENT

The Canadian Forestry Service considers public perception of forest management practices as a potentially critical factor in the success or failure of forest renewal polices, not only in Nova Scotia but throughout Canada.

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4.1 Intensive Forest Management - A Definition

Before proceeding further we should state more precisely what is meant by intensive forest management. Briefly, it means increasing forest growth and yield by suitable use of a variety of practices including the following: (1) site preparation for reforestation; (2) planting or seeding areas in which good natural regeneration is not already established; (3) use of genetically improved seed or planting stock; (4) choosing the most appropriate species for the land in question; (5) spacing and thinning to increase yield and ensure production of tree sizes in demand; (6) pruning and fertilizing where appropriate; (7) better protection and preservation of the growth and ecological and genetic diversity of our forests; (8) more efficient logging and utilization of the crop; (9) harvesting and regenerating the stand at the most favourable time in its life cycle; and (10) concentrating effort on productive and accessible forest land that will give the best return on investment and that will remain as forest land for the time necessary to grow the crop.

4.2 Public Perception and Intensive Forest Management

In the following discussion only those aspects of intensive forest management that have been the subject of public concern are included. Other intensive forest management practices, such as spacing and thinning have not caused concern and are not addressed.

4.2.1 Selection-cutting, Highgrading, and Clear-cutting

There appears to be a demand or at least a strong concensus by the public in favour of forest management. In Nova Scotia however, the public's traditional perception of better forest management is equated with selection cutting, a technique which leaves the forest seemingly intact. The objective of selection cutting is to harvest trees as they mature, allowing young trees to grow in their place. In effect the growth is harvested annually and the forest remains in an unchanging state, in perpetuity. Unfortunately, most of the Province's forests, because of their overmaturity, even age class structure, and species composition are not suitable for selection cutting. What the public, and even some members of the forestry sector, see as selection cutting is actually highgrading.

Highgrading is the practice of harvesting only the best trees in a stand, leaving the low quality trees to regenerate. Such stands are often picked over again and again until all that remains is a scattered forest of low-value trees over-topping regeneration of equally low quality (a silvicultural slum). This forest, which to some is pleasing to the eye, is uneconomical to harvest and extremely difficult to rejuvenate into a productive forest. Usually the only solution is to remove the standing trees, scarify, and plant the area.

Highgrading occurred in the past for purely economical reasons; without modern harvesting machinery, it paid only to cut the biggest and the best. Even now, it is sometimes difficult to determine whether a particular practice is actually selection cutting or highgrading. The irony is that the public seems to be demanding that the forest industry "improve its act", but at the same time will only accept a single technique, which like the little girl with the curl, is very very good when its good but when it is bad, it's horrid.

In Nova Scotia about 2800 new clear-cuts averaging 11 ha each, are scattered throughout the Province each year. The total of these cuts in any one year represents less than 1 percent of the total forested area.

Clear-cutting is the removal of an entire standing crop. It is an efficient means of harvesting, which permits the use of all types of harvesting equipment, and leaves the area to regenerate naturally into an even aged forest or to be planted. In many respects, clear-cutting mimics fire or other natural occurances such as budworm, which have been responsible for the even-aged regeneration of the coniferous forest in the past.

This one forestry technique is probably the cause of most of the resentment of the public towards the forest industry, and is invariably associated or blamed on the big companies and their desire to make big profits. Floods, soil erosion, fire, degradation of streams, and the quality of the succeeding forest, lowering of water levels, and lately, subtle (but presently undefined) environmental changes are all attributed "carte blanche" to the practice of clear-cutting. However, the deleterious effects of clear-cutting are undocumented and are, in fact, associated with improper clear-cutting practices, rather than clear-cutting itself.

There have been cases where poorly constructed roads and stream crossing have contributed to stream siltation and erosion; excessively large cuts have resulted in understocking; slash piled along roadsides has provided the initial fuel for wild fire; and small streams have been virtually buried in slash. But all of these are abuses rather than the wise application of a legitimate forestry practice. Far from causing flooding, clear-cuts have tended to extend the length of time of the spring run-off which eases the risk of floods. New and vigorous forests have evolved through a succession of pioneer species, following many of our earlier clear-cuts.

While there are proper and improper ways to do clearcutting, the principal objection by the public is the appearance of the clearcut areas.

The present forest in Nova Scotia is particularly amenable to clear-cutting because 41 percent of the standing crop is overmature. Clear-cutting of such stands, really amounts to the removal of a crop that was about to be harvested, by nature. It is the end result of most practical forestry techniques that can be applied in Nova Scotia. The advantage of clear-cutting is that highgraded stands can be liquidated, ultimately giving rise, either to new natural stands that can be tailor-made by judicious thinning and spacing to almost whatever needs are required, or to fully stocked plantations of genetically improved trees. The age class of the forest can be regulated, easing management decisions, and producing a forest less susceptible to attack by insects.

Clear-cuts are now generally limited to 80 ha and the leaving of riparian strips has become required practice on Crown and company lands. Regulations now in place require proper stream crossings for roadways. In any event, site preparation techniques and subsequent treatment with herbicides, insecticides, or fertilizers, do not begin to approach the intensity to which these practices routinely occur on agricultural land.

4.2.2 Site Preparation

Site preparation is undertaken to make it physically possible to plant trees by reducing slash and debris, to provide planting sites for seedlings and to reduce competition to the potential crop. By breaking up the thick layer of raw humus and mixing it with the mineral soil, nutrient release is enhanced, the seed bed moisture regime is stabalized and the survival of natural or artificial regeneration is greatly enhanced. Again, the methods now used in large measure replace fire and windthrow in the natural succession in the coniferous forest. Mechanical techniques range from full exposure of soil by plowing or disking, to partial soil exposure by a variety of mechanical equipment, and to simple removal of slash by raking or prescribed burning.

About 5 830 ha were site prepared in Nova Scotia in 1981, representing approximately 17 percent of the area harvested, as compared with 550 ha treated in 1975/76. When the Province's planting program is fully under way (1984), areas site prepared will be in the vicinity of 9 000 ha. Over a 20-year period, this area, which will be distributed across the Province, will represent less than 4 percent of the forested land.

Site preparation techniques, particularly use of the Finnish plow, Marden roller, or prescribed burning, present a picture of abject devastation to the public eye. The similarity of purpose between the plowed field in agriculture and the site prepared cutover in forestry is lost, and concern regarding possible adverse environmental effects arises.

Many site preparation techniques leave unsightly areas for a short period of time, and nothing really can be done about this. There are environmental effects. Certainly habitats are changed, first, because of the harvest, which would have occurred in any case even if the crop died a natural death, second, because of the site preparation treatment, and third, because of the new forest which will eventually inhabit the site. It is possible to list a variety of subtle changes that might occur to the ecology of a particular site, but it is not possible, with present knowledge, to say with certainty whether these changes are good or bad. However, an indication that the changes are not detrimental is the healthy growth of the trees planted. Since it is bad economics to plant trees that don't grow, it behooves the forest manager to treat his planting sites properly.

The method employed by the forester should depend on the nature of the site to be planted, rather than on the equipment available, and the objective should be to obtain maximum planting success with minimal disturbance to the site. These ideals have not always been met, but as forestry agencies gain more experience the success rate will undoubtedly increase.

4.2.3 Plantations

Roughly one-third of the cutover areas in Nova Scotia do not adequately regenerate to desirable softwood species. These areas must, therefore, receive some silvicultural treatment, such as planting, if they are to contribute to wood supplies over the next 40 years. By the year 2020, at the current rate of planting, plantations will cover about 10 percent of the forested land of the Province, some of which will be on abandoned farmland. By comparison, in the past 20 years about 5 percent of the forested area has been lost to agriculture, housing, highways, power dams, and power lines. If this trend were to continue, land used for plantations would roughly equal that being lost to forestry.

In agriculture, as operational costs have increased, the industry has remained viable by increasing yield per acre. The forest industry is striving towards the same objective. By planting trees on cleared areas, optimum stocking can be achieved. Although these clear-cuts will regenerate naturally over varying lengths of time, the degree of stocking is a matter of chance. Optimum stocking can usually be achieved only by fill-planting understocked areas and spacing those that are overstocked. The plantation approach has additional advantages in that superior stock can be planted, species composition controlled, and harvesting costs reduced.

The principal argument against plantations is that they are 'unnatural', exist in large "monocultures", and are therefore susceptible to devastating disease and insect attack. The question of whether plantations are particularly susceptible to insects and disease attack is not substantiated. Moreover, from the limited size of clear-cuts and the extent of the present planting program, it is evident that there are in fact no large monocultures.

The future for plantation forestry is unlimited and could even lead to land requirement reduction for forestry. With increasing knowledge through world-wide research, optimum mixes of species and age classes can be planted, which will enhance existing forest sites, and can be designed to minimize risk from fire, insects, and disease. The science of tree genetics is producing superior stock that will significantly increase yield. These advances will take time and can best be obtained through a gradual modification of existing, admittedly for the time being, imperfect plantation programs. Even so, the plantation successes, to date, have permitted the Province to increase its present harvest in anticipation of resulting increased yields in the future.

On large-scale, long-term planting operations, the basic problem is scheduling. Harvesting schedules are dictated by markets and are relatively flexible. Nursery schedules are planned two or three years in advance and are relatively inflexible. Long-term planning is essential to assure that suitable plantation stock is available at the proper time as areas are cut.

4.2.4 Herbicides

Herbicides are used in conjunction with most site preparation techniques to remove competition at the time of planting, and to protect the crop for the first few years until it can survive on its own. Usually no more than two treatments are required in the lifetime of a plantation. In naturally regenerating young stands following clear-cuts, often only one treatment is required.

In 1981, 74.6 ha of land, representing 1.1 percent of the total area prepared for planting, was treated with herbicides.

The principal objection to herbicide use is the suspected risk to human health and the affront to the environment. Herbicide usage has also been perceived incorrectly as an attack against the Province's hardwood forests. Pressure by some groups of citizens has effectively prevented the use of, at least temporarily, 2, 4-D and 2,4,5-T for treatment of plantations, even from the ground.

Herbicides are one of the most effective means of removing naturally occurring competition. For example, in softwood plantations, pioneer species of hardwoods such as cherry, red maple, grey birch, and poplar plus herbaceous plants such as raspberry, grow very rapidly, can overtop planted trees, and deprive them of light, nutrients, and moisture. This doesn't always happen but it often does. When it does happen a large proportion of the seedlings, raised in nurseries and outplanted at great cost, die. Natural softwood regeneration is also overtopped with similar vegetation and although most of the overtopped trees survive, they are slow to develop.

At present 2,4,5-T and 2,4-D are the principal herbicides registered for forest use in Canada. Agriculture Canada, the agency responsible for the registration of pesticides, has not wavered in it's support of these chemicals for forestry use, in spite of intense pressure from groups opposing their use. Hand weeding has been offered as an alternative to herbicides on the assumption that it is safe. Estimates of costs for manual weeding vary from $740 to $1 110 per ha per treatment as compared with $197 to $247 per ha per treatment for ground application of herbicide, and $54 to $74 per treatment for aerial application. The accident rate in the USA for workers involved with chemical application of herbicides was 0.07 accidents per 100 000 working hours as opposed to 6.7 accidents per 100 000 working hours using manual methods. Furthermore, hand weeding cannot be done until the plantation is well established because of the risk of mechanical damage to the small crop trees, and thus provides no benefit in the early establishment phase.

4.2.5 Insecticides

Over 3000 species of potentially destructive insects and about an equal number of diseases occur in Nova Scotia forests, but most of these are controlled by their natural enemies and cause little damage. A small number of these pests, such as the spruce budworm, occasionally outstrip their natural controls and become full fledged pests. In some of these cases the only known way of limiting the impact on the forest is through the judicious use of insecticides.

From 1977 to 1981 an average of 44 pests caused an estimated annual loss of wood fibre amounting to 4.1 million m^3 in Nova Scotia. By far, the greatest part of this loss (3 148 068 m^3) has been caused by the spruce budworm.

The effect of the spruce budworm can be devastating. In uncontrolled outbreaks the larvae feed on the buds, flowers, and needles of fir, spruce, hemlock, and tamarack. The repeated removal of the current year's growth reduces stored food, growth hormones, radial and height growth, and results in loss of seed crops, rootlet mortality, and eventual death. Outbreaks usually last 8-10 years and terminate when the food supply becomes scarce because tree mortality is widespread. Even after the budworm populations subside, trees continue to die for several years with Armillaria root rot, bark beetles, and other secondary pests hastening the death of weakened trees. Balsam fir dies after four to five years of severe damage (>80% of current year's foliage removed) while white and red spruce may withstand up to 6 years of severe defoliation. Black spruce, particularly in pure stands, usually survives.

Aside from direct attacks on the forest resource, insects can cause serious problems in nurseries and seed orchards, which are the cornerstones of the Province's reforestation program. For example, a 10 percent loss, due to an uncontrolled pest problem in a nursery in a 10 million seedlings/year plantation program, requires the extra production of one million seedlings, or results in 400 ha not being planted. Not all affected seedlings die. Some survive and after outplanting become the source from which the pest spreads, infecting other trees in the plantation and spreading the problem to new areas. A good example of this occurred when red pine seedlings infested by the European pine shoot moth were widely planted throughout the Province. The insect was first found in Nova Scotia in 1925, now it is almost impossible to find a "clean" plantation.

Other coniferous pests such as the balsam gall midge, balsam twig aphid, needle rusts, needle casts, stem rusts, sawflies, root rots, etc. cause mortality, deformation, and retarded growth. The importance of these is further magnified in Christmas tree plantations because of the high value of individual trees. Pests of seed orchards and plantations also present special problems because of the major investments and critical importance of such areas in the Province's forest management program.

The Province has responded to some of the above problems with several control strategies.

In 1982, aerial applications of the pesticide Bacillus thuringiensis (Bt) were applied to 18 524 ha of spruce and fir forest infested with the spruce budworm in Cumberland County. The objective was to save 50 percent of the foliage. Black spruce seed collection areas were also treated, totalling 370 ha in Cape Breton. Applications were confined to areas remote from human habitation and were in response to the general spruce budworm infestation that caused moderate to severe defoliation on 567 000 ha of forest, the previous year. This was the fourth year of such operations by the Province using Bt. This insecticide was also used on shade trees in Yarmouth in an attempt to eradicate introduced populations of the gypsy moth.

There are currently two other insect control operations that have been underway for the past few years using biological control techniques; 1) an insect parasite was released against the larch sawfly, and 2) attempts were made to increase the effectiveness of a previously introduced parasite of the European pine shoot moth by encouraging the growth of wild carrot as a special food for the parasite which increases its fecundity. So far, neither of these attempts have produced any effect on the populations of the two pests.

The use of pesticides in forestry is regarded with suspicion by the public. They are concerned over human health hazards and risks to the environment. There is also concern that the persistent use of insecticides can so disrupt the natural controls and balances in the population dynamics of a particular pest, that control by other than chemical means becomes impossible. And finally, there is a concern amongst some biologists that repeated insecticide application in forestry operations may lead to the development of resistant strains and thereby increase the difficulty of chemical control.

Chemical pesticides are toxic materials which produce risks to humans and cause ecological upset when broadcast over large acreages of forest lands. Such risks have to be measured, evaluated, and weighed against the benefits of a particular control operation, and against the counter-risks of no action or alternative action.

The Department of National Health and Welfare is responsible for advising Agriculture Canada on the risk evaluation regarding human health in the pesticide registration process. That evaluation takes into account use patterns, exposure probabilities, and the environmental toxicology of the chemical or pathogenic formulations. The classes of public exposure are occupation (pesticide mixers, pilots, and airstrip workers); bystanders (woodworkers, fishermen, and others inadvertently present in the spray block); and the distant populace (exposed to possible long-range drift of the spray cloud). The registration process establishes use patterns for each approved insecticide, such that health risks are estimated to be, in the judgment of the Minister, sufficiently low for routine practice. The permitted dosage incorporates large safety margins to account for variations in human susceptibility and for deviations from the models used in toxicological tests.

The Department of Agriculture, with the assistance of other federal departments, evaluates the risk in the biological environment. The Department has the prime responsibility for the Pest Control Products Act. Its information base for conduct of the registration process is an international data bank on environmental chemistry, field efficacy, and product harard. Hazards in the environment, both as to human health and ecological disturbance, are estimated from toxicological investigations (acute and chronic) of various animals and plants under a protocol of laboratory and field experiments. The data base for a single pesticide candidate is usually gathered over many years at a cost of many millions of dollars, with input by chemical companies, consultants, foreign agencies, federal agencies, universities and others.

It is in the nature of risk evaluation that no chemical including pesticides, and no use pattern can ever be considered safe i.e., zero-risk. Unknown factors and unforeseen toxic pathways impose caution on any judgment of acceptability. Therefore, Provinces have seen fit to establish a second safety screen based on regional conditions and provincial values, and which is applied by provincial boards who licence applicators and issue permits for spray operations. They frequently impose additional stringent conditions on the usage of a pesticide.

The third screen for safety - with respect to insecticide application and ecological effects - is the environmental surveillance conducted by field scientists. Such monitoring committees are in place in New Brunswick, Newfoundland, Quebec, Ontario, and the State of Maine, to detect and quantify ecological risks for which documentation is weak or where new doubts have arisen. The reports from these committees serve well to measure the persistence, movement, and effect of toxic chemicals in specific situations; but so far they have not suggested that long-term risks to wildlife are being compounded by continued extensive spraying. A report from the New Brunswick Committee concluded on the basis of scientific studies in 1978-79 and earlier in eastern Canada, that current spray practices in New Brunswick produce no effects evidently damaging to the conservation and sustained-yield management of fish and wildlife. There was no support for the hypothesis that registered insecticide use-patterns interfere damagingly in the long term with natural productive processes and relationships within ecosystems.

There are numerous examples in agriculture of insect species developing resistance to insecticides, particularly during the DDT era. With the possible exception of an apparent developing resistance of the spruce budworm to DDT during the early to late 1960's, there is no documented evidence of a forest insect developing insecticide resistance as a result of forest insect control operations. The reason for this difference between agriculture and forestry has to do with a substantial difference in selection pressures. In forestry, the objective of pest control operations, except in very unusual circumstances, has been to keep trees alive until they will be harvested. As a result dosages and frequency of application tend to be low and percentage kill of the pest population seldom exceeds 80 percent. In agriculture, on the other hand, the objective is to reduce damage to a mimimum with the result that dosage and frequency of application tend to be higher, and kills of the pest are frequently in excess of 95 percent - a situation that has a much higher probability of resulting in the development of resistant strains of pests.

There is evidence that forest insect control operations can cause damage to natural enemies of pests. However, in all cases where the extent and duration of an effect have been investigated, it has been found that populations of the natural enemies rebound to their prespray levels within one or two years after spraying. In fact, there is evidence, involving the spruce budworm and DDT, that aerial spraying of an insecticide can result in an increase in density of some natural enemies of the pest.

Forest protection, by whatever means, is an essential part of forest management. Otherwise, insects and diseases, not man, will harvest the forest resource. As investments in intensive forest management in Nova Scotia increase, so does the need for an adequate forest protection policy.

4.2.6 Fertilizers

The principal purpose of fertilizers in forestry is to increase growth and to ameliorate forest sites that for some reason have suffered nutrient losses or are of inherently low nutrient status. Christmas tree producers use fertilizers to improve colour and foliage density and thereby improve product quality.

Fertilizers are used extensively in the Christmas tree industry in Nova Scotia. No precise figures are available, but based on Christmas tree production, 8 000 ha are probably treated annually. There are presently no commercial treatments of forests or plantations, although fertilization of young stands, in combination with planting or spacing, may become an acceptable silvicultural practice within the next decade.

Fertilizers can be a source of pollution. In particular, they are accused of causing eutrophication of streams and lakes, which means increases in growth of water plants, such as algae, followed by subsequent oxygen loss, and eventual death of fish.

In the Christmas tree industry, fertilizers, which are generally high in nitrogen, are applied early in the spring and are taken up rapidly by the foliage. Perhaps, 450 tonnes of nitrogen fertilizers and lesser amounts of potassium and phosphorus are applied annually. The quantities applied and the areas treated in forestry operations are so small that no deleterious effects can be realistically anticipated.

4.2.7 Genetics

Some concern has been expressed about the concept of genetically improved tree species. The basis for this concern is that trees developed for their fibre-producing characteristic may prove susceptible to unforeseen insect and disease problems and may not be fully suited to the Nova Scotian environment.

Prior to the early 1970's, work on forest genetics in the Maritimes region was primarily research. Since that time provincial governments and industries have undertaken substantial applied tree improvement programs. In Nova Scotia, the three major forest industries and the Province have formed a cooperative working group for tree improvement. Within the next 10-15 years a large part of the seeds used for reforestation will be genetically improved, and by this means the quality of the planting stock, and the growth and quality of the resulting plantations will be increased.

Trees used in applied improvement programs are selected on the basis of superior growth and quality with lesser emphasis on insect and disease tolerance. Selection for or against other characteristics is essentially random. As the selected trees are from a wide area and are unrelated to each other, the genetic variability of the improved populations will actually be greater than in existing wild stands.

4.2.8 Forest Utilization

The extraction of maximum benefit from the timber resource of the Province is an integral part of intensive forest management.

The annual harvest of sawlogs in Nova Scotia has averaged around 1.0 million m^3 during the past 17 years. By contrast, other roundwood production has increased from 2.0 to 3.3 million m^3.

The loss of so much mature timber to the spruce budworm in recent years, has put considerable pressure on the younger stands in the Province as a source of green wood. The smaller average size of logs is a problem to the sawmills not equipped to process small wood profitably. In addition many of the native species do not lend themselves to the production of salable commodities on today's world markets.

Most of the apprehension and complaints regarding full utilization of the forest resource is directed at logging waste and the under - or non-utilization of native species. At present, harvesting costs and world markets dictate in large measure, the products retrieved from the forest resource. As pressure on the limited resource builds for more goods and services, it will become profitable to utilize more species, reduce logging waste, and increase processing efficiency. The softwood shortage may force changes in pulping processes to enable greater utilization of low-grade hardwoods.

4.3 Current and Future Efforts to Respond to Public Concerns Regarding Intensive Management Techniques

4.3.1 Insecticides and Herbicides

Pesticide use has been a particularly controversial subject in forest management in Nova Scotia. A strong polarization of views separates these who oppose pesticide use as a source of danger to public health and those who support it as a necessary tool for forest management. Political decision-making and policy development have become very difficult in the confrontation which exists, but have become crucial to the well-being of a much broader public than the restricted groups now involved in the debate.

It must be recognized that a "zero risk" requirement is impossible to meet. One cannot prove or demonstrate a negative. Further, all human activity entails some degree of risk, as would testify the lady who was struck by a meteorite while sleeping in her own bed. It is therefore essential to define and determine an acceptable level of risk in relation to benefits, a process which must balance economic benefits, risk and societal attitudes to determine the required level of control and regulation. This is not a new process. We have done just that with gasoline and the motor vehicle.

The factors to be considered in this process as it relates to pesticide use must include objective scientific evaluation of risk, particularly the stringent registration procedures of Agriculture Canada. They must also include the economic impacts, direct and indirect, on the large number of Nova Scotians who will be affected by the eventual decisions. Most important and most difficult, they must include the attitudes and perceptions of risk and benefits to the Nova Scotian public. In this last element, it is crucial that these perceptions be those of a wide constituency and a well-informed one. Otherwise, the present conflict could result in foreclosure of forest resource management options open to society for decades to come.

In view of the ever increasing investment by both the Province and the Federal government in extensive forest management, the Province should begin immediately to design, develop, and put into practice a forest protection policy that will protect this investment and help assure the attainment of forest management objectives.

In addition, the Province should put in place a public information program that will explain its protection policy before, during and after institution of protection programs.

In the design and subsequent conduct of a forest protection policy the Province should recognize and take full advantage of the stringent pesticide registration process of Agriculture Canada.

4.3.2 Other Intensive Forest Management Practices

Public disapproval of clear-cutting and site preparation is justified if these two practices are abused. Therefore, the Province should design and stringently enforce, and be seen to enforce, regulations with respect to road construction, leaving of riparian strips (except where the risk of wind-throw is obviously high), stream crossing, protection of deeryards, etc. and other environmental protection measures.

Regarding the unsightliness of clear-cutting and site preparation operations, the Province should establish guidelines to improve the appearance of roadside forestry in the manner illustrated in the Nova Scotia Forest Industries brochure "The Forest Landscape." Coupled with this, the Province should conduct an information program that will explain and justify the need for clear-cutting, site preparation, and plantation, establishment.

Finally the Province should initiate a demerit system, perhaps with financial penalties, that will discourage woods operators from leaving forestry operations in a more unsightly state than is necessary.

4.3.3 Forest Utilization

Full utilization of the forest harvest can have a positive influence on public attitudes toward forestry and the greater the variety of goods that can be produced the better.

The fuel crisis is one area in which the public's interest in forestry has been aroused. The interest is largely in fuelwood, but also extends to fuel pellets and gasoline substitutes.

Aside from such direct uses of the forest resource, production standards for sawn products must be improved. Mills must strive to produce a better product to remain competitive. For processing short hardwood logs under 2.4 m in length, specialized equipment is needed. More attention should be given to the increased use of dry kilns, to produce such products as furniture dimension stock. If the present study on the "Increased Use of Wood for Energy in Nova Scotia" shows an abundance of low quality hardwoods superfluous to fuelwood requirements, thought could be given to expanded hardboard production or establishment of a waferboard plant. As demand continues to build on the limited resource, it will become essential to utilize all species and improve utilization standards by reducing logging waste and increasing processing efficiency. Integrated woods operations should be conducted wherever economically feasible so that maximum return is obtained from available fibre.

5.0 PUBLIC INFORMATION

No forestry programs involving large investments of public funds can or should be continued without public support. Unfortunately, public understanding of forestry issues has decreased markedly in recent times, partly through the shift from rural to urban environments.

Public debate cannot be effective unless it is conducted by an informed public. Neither can it be effective unless it involves a wide constituency of interests covering the whole range of affected and interested citizens. In forestry the stakes are simply too high to permit decisions that will affect the long-term well being of this vitally important industry to be determined without public knowledge. Effective programs that will inform the public on all aspects of forest management should be launched.

Under the 1977 Federal/Provincial Forestry Agreement, the major thrust of the public information program was directed towards the youth of the Province, through such excellent publications as the "The Man Who Couldn't Stop Sneezing", "The Brook and the Woodcutter" and programs involving teachers, 4H groups, etc. The main part of the Canadian Forestry Association program is also youth oriented through such projects as the Learning Tree. While such programs should increase the awareness of tomorrow's adult public, they do not have sufficient impact on today's adult public - the voter who largely influences the setting of present day forestry policies and programs. Public education programs directed at youth should, without question, be strengthened and continued, but new education programs directed at adults should be initiated as soon as possible. The forestry story has to be told, accurately and honestly.

6.0 ROLE OF RESEARCH AND DEVELOPMENT IN THE IMPROVEMENT OF FOREST MANAGEMENT TECHNIQUES

Until recently, there was a widespread perception of forestry researchers as long-haired, white-coated dwellers in ivory towers, who pursued knowledge for its own sake and whose activities bore little or no resemblance to the "real world" outside. Undoubtedly, such a perception was valid to a certain extent, but much of it was myth fueled by poor or nonexistent communication between the scientist and forest manager and by the then unreadiness of forest management agencies to practice many of the findings of the scientists.

In the last few years this scenario has changed dramatically. Propelled by impending wood shortages, the practice of forest management has become much more intensive, and in the process has generated a vastly increased demand for information and advice on a great variety of forestry topics. At the same time, the realization has dawned on the forestry research agencies that the knowledge and information they are generating, even now, at a time of high demand, are of little or no value if not put to use in forest operations or planning.

Recent developments in forestry practice have in many ways vindicated the scientists of earlier decades, who knew the problems they worked on had to be addressed, yet saw little or no use made of their results and received little recognition of their contribution beyond the inner circles of science. Now we are finding that intensive management techniques and procedures are critically dependent upon information generated 10, 20, even 30 years ago. Were it not for that earlier research, we would not be able to mount intensive forest management programs with the assurance and the ambition we now do. Work on spruce budworm and other insect pest biology and control, on species selection, testing of exotic tree species, spacing and thinning, and plantation establishment, on soils and cover types and forest productivity, and so on, much of it carried out 10 or more years ago, is the keystone of today's forest management decisions. Indeed, our biggest regret now is that there is not more of this information to draw upon; we now find ourselves scrambling to refine or extend this earlier knowledge, make it specific enough to cover the many sites, species, cover types, and management situations of interest to us.

But enough of the past. What then are our major forestry research and development problems and challenges right now?

Firstly, it is obvious that we must make immediate and full use of all information that already exists. To do this, we have created and are still in the process of expanding a Technical Services group at the Canadian Forestry Services' Maritimes Forest Research Centre, Fredericton, whose purpose is to provide the linkage, in the form of advice, demonstration, operational research, and short-term testing, between the researchers and the forest practitioners. This group interfaces with Provincial extension staff and through them to company foresters and woodlot owners, to convey research information to them and to bring their concerns and needs to the attention of the researchers. Other mechanisms to this same end include the Nova Scotia Forest Research Committee, which is a forum for Federal/Provincial/Industry exchange of information and planning of joint efforts, and the newly-signed Canada/Nova Scotia Agreement on forestry research, which identifies a number of major research and development topics of concern at this time, and assigns lead responsibility for tackling them.

Secondly, it is imperative that we maintain and reinforce the ongoing research effort. It is crucial that we sustain a balance between basic or long-term research, whose function is to advance our knowledge base, and applied research and extension-type functions, whose purpose is to ensure application of information we already possess. Basic research without application is largely wasted effort, while applied work in the absence of an ongoing basic research effort would soon run out of new information to apply.

Conversely, we will not be able to follow through on the more intensive and precise forest management programs to do this unless research continues and increases its supply of information to facilitate these actions.

7.0 EXTENSION

A classic story on agricultural extension goes this way: After listening patiently to the agriculture extension man, who spilled out advice on the many ways the farmer could better manage his land, the farmer said "I'm only farming now half as well as I know how to." He might also have said: "It's my land and I'll manage it how I please." Over 52 percent of Nova Scotia's forest land is owned by private individuals, many of whom could react exactly as the farmer in the story. This is the situation facing the extension forester. If he is unsuccessful in convincing more than 60 percent of the woodlot owners to include their forests in the Province's grand scheme for forestry, there will be, a disasterous shortfall in the wood supply for forest industries in the next 20 years.

The extension forester's job is to provide the woodlot owners with information that will influence him positively to practice intensive forest management on his land and then, once he has made this decision, to provide him with advice.

Another critical factor, however, is each woodlot owner's attitude to long-term management programs. For him the question is not whether long-term management is good or bad, but very simply, what's in it for him. It is in the Province's best interest for the woodlot owner to place his woodlot under long-term management, for in the long run the survival of the forest industry is dependent on woodlot owner participation.

The previous Federal/Provincial Forestry Agreement addressed the problem of woodlot owner participation with incentives and an education program. The incentives program which funded boundary lines, roads, and silviculture was an unqualified success at creating interest among woodlot owners as is evidenced by the fact the program could not meet the demand. The educational program provided woodlot owners with the means to become more knowledgeable about forest management procedures, through the publication of numerous informative pamphlets on silvicultural techniques and the excellent publication "The Trees Around us." Provincial foresters prepared management plans and provided information and advice on forest managment techniques. These programs will continue under the new Federal/Provincial Forestry Agreement.

The importance of the extension program cannot be understated. The future of forestry in Nova Scotia depends on participation of the small woodlot operator. In the short term, incentives are helpful, even essential, but in the long term, education and information are the only tools that will continue to foster, among woodlot owners, a forestry ethic and a positive attitude toward proper utilization of the forest resource entrusted to them.

8.0 ACID RAIN

The subject of acid rain is included here because, along with the vagaries of markets, wild fires, and insects and diseases, it may have some effect (presently imponderable) on the future of forestry in the Province.

The term acid rain is applied to precipitation which is contaminated by the sulphate ($SO\underline{?}^{=}$) and nitrate (NO_3^{-}) oxidation products of man-made sulfur dioxide (SO_2) and nitrogen oxide (NO_x) gaseous emissions and which has a pH balance below 5.6. Eastern Canada lies within the potential long-range transport distance of approximately 30 and 24 million tonnes of sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions per year, respectively. In Nova Scotia, about 30 percent of the $SO\underline{?}^{=}$ deposition is contributed by local sources.

There is as yet no unequivocal evidence of forest damage in Nova Scotia due to acid rain. However, studies in a laboratory simulated rain environment using the mean 1980 rain chemistry for central New Brunswick have demonstrated alterations in the tree seedling development rate and form, of several commercially important coniferous tree species. Other research has demonstrated deleterious effects in deciduous species, and still other work has indicated that acid rain may interfere with pollination and also create conditions that favour the spread of plant diseases. It should be pointed out that all of these findings are based on laboratory-derived data. Acid rain may also affect the internal nutrient cycling processes within forest stands by removing beneficial plant nutrients from the foliage as it passes through the tree canopy. A number of indirect effects of acid rain on the forest can also be hypothesized from soil chemistry studies. Excess hydrogen ion deposition, such as that in acid rain, can lead eventually to decreases in soil pH, the leaching of soil nutrients, and the increased availability of toxic heavy metals. Biological processes such as organic matter decomposition, and nitrogen transformation may also be adversely affected.

How sensitive, then, are the forests of Nova Scotia to acid rain? The sensitivity of Nova Scotia bedrock and soils derived from bedrock is known to be high, or high to intermediate. There is at present no such data regarding vegetation sensitivity, although some initial research has been completed. Therefore, the precise impact of acid rain on the Nova Scotia forest has not yet been elucidated.

9.0 RECOMMENDATIONS

1. The Intensive Forest Management Programs as outlined in the present Canada/Nova Scotia Forestry Agreement should be continued to maintain the forest industry and forestry employment.

2. A wood allocation plan, should be devised to alleviate projected regional wood supply problems, which will occur by the year 2000.

3. The Group Venture Program should be fully supported and efforts increased to encourage greater participation.

4. A Provincial Forest Protection Policy that will protect the forests of Nova Scotia, particularly where silvicultural investments have been made and thereby help secure the future of forestry in Nova Scotia, should be designed and implemented immediately.

5. Public information programs should be implemented that will explain the Province's protection policy before, during and after institution of protection programs. This will ensure that a broader public base will be brought into the decision making procession.

6. The pesticide registration process of Agriculture Canada, perhaps the most stringent in the world, should be fully explained, particularly its role in protecting human health and environmental quality. In addition, it should be fully supported.

7. Technology transfer programs should be increased to improve the productivity and profitability of small woodlots.

8. Public concern over the perceived effects of intensive forest management should be addressed by the adoption and stringent enforcement of regulations governing road construction, riparian strips, protection of deeryards, and other measures to maintain environmental quality.

9. Guidelines that will improve the appearance of roadside forestry in the manner illustrated in the Nova Scotia Industries' brochure "The Forest Landscape" should be adopted.

10. A demerit system, perhaps with financial penalties, that will discourage woods operators from leaving forestry operations in an unnecessarily unsightly state should be considered.

11. Support for forestry research and development should be increased.

12. Present public forestry education programs should be strengthened with more emphasis placed on the adult public who influence political decisions. The forestry story has to be told, accurately and honestly.

13. The Province should recognize the potential for damage to the forest from acid rain, and support research both within the Province and elsewhere.

10.0 BIBLIOGRAPHY OF SELECTED SUBJECTS

10.1 Acid Rain

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11.0 APPENDICES OF DATA RELATING TO FOREST ECONOMICS, WOOD SUPPLY, HERBICIDES, AND LOSSES TO THE FOREST RESOURCE FROM FOREST INSECTS AND DISEASES

Appendix	
I	Forest Industry Statistics for Nova Scotia, 1979.
II	Leading Manufacturing Industries in Nova Scotia Based on Number of Production and Related Workers, 1979.
III	Leading Manufacturing Industries in Nova Scotia Based on Wages Paid, 1979.
IV	Leading Manufacturing Industries in Nova Scotia Based on Value Added 1979.
V	Leading Manufacturing Industries in Nova Scotia Based on Value of Shipments.
VI	Timber Harvest in Nova Scotia.
VII	Timber Harvest in Nova Scotia by Major Products, 1967-1980.
VIII	Nova Scotia Land Distribution by Capability Class and Productivity Ranges.
IX	Softwood and Hardwood Species in Nova Scotia in Order of Relative Abundance.
X	Comparative Costs of Chemical and Manual Plantation Cleaning Methods.
XI	Forest Fires in Nova Scotia 1966-1980.
XII	The Number of Forest Pests Which Caused Severe or Moderate Problems at Least Locally in Nova Scotia in a 10 Year Period (1972-1981).
XIII	Economically Important Forest Pests Recently Discovered in Nova Scotia.
XIV	Losses by Some Selected Forest Pests in Nova Scotia a. Spruce budworm b. Spruce beetle c. Larch beetle

e. Hypoxylon canker

f. White pine blister rust

g. Decays and culls

h. Dutch elm disease

i. Volume of tree mortality caused by forest pests in Nova Scotia (1977-1981)

APPENDIX I

Forest Industry Statistics for Nova Scotia, 1979

Sector	Employment[a]		Value added[a]	Value of shipments
	No. of Employees	Salaries & wages $000	$000	$000
Logging	1 178	14 478	28 578	92 346
Wood industries	2 151	23 263	49 274	91 571
Sawmills	1 257	13 655	26 539	49 138
Other[b]	894	9 608	22 735	42 433
Paper & allied industries	3 175	58 830	168 437	315 507
Pulp & paper	2 522	50 998	152 264	278 621
Other[c]	653	7 832	16 173	36 886
Total, forestry	6 504	96 571	246 289	499 424

[a] Employment and value added are for total activity. Therefore figures are larger than those presented in following tables, which are based only on manufacturing activity.

[b] Includes shingle mills, veneer and plywood plants, millwork, box factories, etc.

[c] Includes paper box manufacturers, paper converters, asphalt roofing plants.

Source: Statistics Canada, 25-202.

APPENDIX II

Leading Manufacturing Industries in Nova Scotia Based on Number of Production and Related Workers, 1979.

Rank	Industry	Production & related workers	%
1	Fish products	5 181	17.7
2	Pulp & paper mills	1 865	6.4
3	Shipbuilding & repair	1 304	4.5
4	Sawmills & planing mills	1 093	3.7
5	Dairy products industry	576	2.0
6	Publishing and printing	570	2.0
7	Communications equipment	510	1.7
8	Bakeries	496	1.7
9	Fruit & vegetable canners	387	1.3
10	Petroleum refining	362	1.2
	Other	16 003	57.8
	All industries	29 247	100.0

Source: Statistics Canada, 31-203.

APPENDIX III

Leading Manufacturing Industries in Nova Scotia Based on Wages Paid, 1979

Rank	Industry	Wages paid ($000)	%
1	Fish products	58 894	14.7
2	Pulp & paper mills	36 738	9.2
3	Shipbuilding & repair	18 527	4.6
4	Sawmills & planing mills	11 225	2.8
5	Petroleum refining	8 742	2.2
6	Dairy products	8 275	2.1
7	Publishing & printing	8 016	2.0
8	Communications equipment	6 630	1.7
9	Bakeries	5 138	1.3
10	Fruit & vegetable canners	3 824	1.0
	Other	234 072	58.5
Total	All industries	400 081	100.0[a]

[a] Total may not add to 100.0 due to rounding.

Source: Statistics Canada, 31-203.

APPENDIX IV

Leading Manufacturing Industries in Nova Scotia Based on Value Added[a], 1979

Rank	Industry	Value added ($000,000)	%
1	Pulp and paper mills	152.9	14.8
2	Fish products	109.4	10.6
3	Petroleum refining	61.0	5.9
4	Shipbuilding & repair	36.9	3.6
5	Publishing & printing	30.2	2.9
6	Sawmills & planing mills	26.4	2.6
7	Dairy products	21.4	2.1
8	Communications equipment	19.0	1.8
9	Bakeries	14.0	1.4
10	Soft drink manufacturers	12.4	1.2
	Other	547.1	53.0
Total	All industries	1,030.7	100.0[b]

[a] Value added in manufacturing activity.

[b] Total may not add to 100.0 due to rounding.

Source: Statistics Canada, 31-203.

APPENDIX V

Leading Manufacturing Industries in Nova Scotia Based on Value of Shipments[a], 1979

Rank	Industry	Value of shipments ($000,000)	%
1	Petroleum refining	855.4	26.6
2	Fish products	360.4	11.2
3	Pulp & paper mills	278.6	8.7
4	Dairy products	103.9	3.2
5	Feed industry	52.1	1.6
6	Shipbuilding & repair	50.4	1.6
7	Sawmills & planing mills	49.1	1.5
8	Publishing & printing	39.9	1.2
9	Fruit & vegetable canners	29.9	0.9
10	Communications equipment	29.6	0.9
	Other	1,363.2	42.4
Total	All industries	3,212.5	100.0[b]

[a] Value of shipments of goods of own manufacture.

[b] May not add to 100.0 due to rounding.

Source: Statistics Canada, 31-203.

APPENDIX VI

Timber Harvest in Nova Scotia, 1935-1980

Year	Softwood (000 m3)	Hardwood (000 m3)	Total (000 m3)
1935	1631	236	1867
1940	2507	141	2648
1945	1994	179	2173
1950	1918	145	2063
1955	2854	131	2985
1960	2154	87	2241
1965	2857	74	2931
1970	2848	210	3058
1971	2876	204	3080
1972	2808	301	3109
1973	3071	365	3436
1974	3419	408	3827
1975	3070	286	3356
1976	2961	274	3235
1977	3240	248	3488
1978	3677	278	3955
1979	3739	412	4151
1980	3748	523	4271

Source: Nova Scotia Dept. Lands and Forests.

APPENDIX VII
Timber Harvest in Nova Scotia by Major Product, 1967-1980

Year	Sawlogs (000 m3)	Round (000 m3)	Total (000 m3)
1967	997	1667	2664
1968	1039	2231	3270
1969	1159	2065	3224
1970	1033	2024	3057
1971	801	2280	3081
1972	953	2156	3109
1973	1025	2411	3436
1974	1022	2805	3827
1975	837	2518	3355
1976	957	2278	3235
1977	940	2548	3488
1978	975	2979	3954
1979	1058	3093	4151
1980	960	3310	4270

Source: Nova Scotia Dept. Lands and Forests.

APPENDIX VIII
Nova Scotia Land Distribution by Capability Class and Productivity Ranges

Metric capability class	Productivity range per year		Approximate % of Province in each class
	m3/ha	cu ft/ac	
0	0.0 - 0.5	7	8
1	0.6 - 1.5	8 - 21	15
2	1.6 - 2.5	22 - 36	
3	2.6 - 3.5	37 - 50	
4	3.6 - 4.5	51 - 64	39
5	4.6 - 5.5	65 - 79	
6	5.6 - 6.5	80 - 93	35
7	6.6 - 7.5	94 - 107	
8	7.6 - 8.5	108 - 121	3
9	8.6 - 9.5	122 - 136	
10	9.6 -10.5	137 - 150	1
11	10.6 -11.5	151 - 164	
12	11.6 -12.5	165 - 179	
13	12.6 -13.5	180 - 193	

APPENDIX IX
Softwood and Hardwood Species in the Order of Relative Abundance

Softwoods	% Abundance	Hardwoods	% Abundance
Red/black spruce	27	Red maple	12
Balsam fir	25	Yellow birch	6
White spruce	7	Sugar maple	4
White pine	5	White birch	3
Hemlock	3	Aspen	2
Larch	1	Beech	2
Red pine	1	Red oak	1
		White ash	1
Total	69	Total	31

Source: Provincial Forest Inventory.

APPENDIX X
Comparative Costs of Chemical and Manual Plantation Cleaning Methods

Method	Cost/ha for treatment $	No. of treatments per plantation	Gross cost/ha $	Relative accident rates annually, USA
Brushkill (aerial application)	54-74	2	109-148	0.7 accidents per 100,000 working hours
Brushkill (ground application)	197-247	2	395-494	
Manual	740-1110	4	2964-4446	6.7 accidents per 100,000 working hours

APPENDIX XI
Forest Fires in Nova Scotia 1966 - 1980

Year	Number of fires	Area burned Acres	Area burned Hectares
1966 - 1975	5930	44 780.0	18 091.1
1976 - 1977	541	43 331.0	17 505.7
1977 - 1978	633	2892.4	1 170.5
1978 - 1979	793	1824.9	738.4
1979 - 1980	682	1865.1	754.7
1980 - 1981	439	2418.7	979.3
Total 15 years	9018	97 112.1	39 239.7
Average/year	601.2	6 474.1	2 616.0

Source: Nova Scotia Dept. Lands and Forests Annual Reports.

APPENDIX XII
The Number of Forest Pests Which Caused Severe or Moderate Problems at Least Locally in Nova Scotia in a 10-year Period (1972-1981)

Year	Softwoods Insects	Softwoods Diseases	Hardwoods Insects	Hardwoods Diseases
1972	11	10	8	9
1973	13	10	14	7
1974	13	8	11	5
1975	9	9	13	14
1976	7	7	6	8
1977	13	12	16	16
1978	15	11	12	7
1979	9	6	20	10
1980	13	8	16	11
1981	17	9	14	10
Total	120	90	130	97

Source: Forest Insect and Disease Survey Annual Reports,
Maritimes Forest Research Centre, Fredericton, N.B.

APPENDIX XIII

Economically Important Forest Pests Recently Discovered in Nova Scotia

Year	Organism
1972	- Scleroderris canker - *Gremmeniella abietina*
1974	- Shoot blight of conifers - *Sirococcus strobilinus*
	Needle rust of pine - *Coleosporium viburni*
1975	- Introduced sawfly - *Diprion similis*
	Douglas fir needle blight - *Rhabdocline weirii* var. *oblonga*
1977	- Larch bettle - *Dendroctonus simplex*
1980	- European larch canker - *Lachnellula willkommii*
	European pine sawfly - *Neodiprion sertifer*
1981	- Gypsy moth - *Lymantria dispar*
1982	- Douglas fir needle blight - *Rhabdocline pseudotsugae*

APPENDIX XIV

Losses by Some Selected Forest Pests in Nova Scotia

(a) Spruce budworm - Choristoneura fumiferana

The spruce budworm has caused noticeable defoliation in some parts of Nova Scotia every year since 1951 with the exception of a three-year period from 1963 to 1965. The records for the last 11 years follow.

Year	Area of defoliation by classes (ha)			
	Severe	Moderate	Light	Total
1971	161 000	20 900	45 500	227 400
1972	115 400	24 800	15 900	156 100
1973	88 900	?? ?	?? ?	88 900+
1974	--- ---	353 600	— ——	353 600
1975	690 000	187 500	?? ?	877 500+
1976	690 000	530 000	115 000	1 335 000
1977	777 100	46 000	115 000	938 100
1978	452 000	101 000	214 000	767 000
1979	359 000	168 000	564 000?	1 089 000
1980	492 200	224 200	662 8002	1 379 200
1981	410 800	156 200	133 000	700 000

?Includes 339 000 ha 'variable' defoliation - a mixture of severe-moderate-light patches.

2Includes 558 800 ha 'variable' defoliation.

Source: Annual reports of the Forest Insect and Disease Survey, MFRC Fredericton, N.B.

Mortality of balsam fir and spruce has been confined mainly to Cape Breton Island and Cumberland County during the past few years. Losses due to mortality from 1977 to 1981 have been estimated as follows.

Year	Budworm mortality of fir and spruce (m3)
1977	2 208 800
1978	3 332 800
1979	3 095 800
1980	3 475 900
1981	3 627 000
1977-1981	15 740 300
Average annual mortality of fir and spruce	3 148 060

Source: FIDS depletion estimates for CFS National Forestry Statistics, approved by N.S. Lands and Forests.

The over 3.1 million m3 annual loss represents an annual depletion of over 5% of susceptible forest inventory or 80% of Nova Scotia's total allowable cut from production forest land (ref. Table A30, Canada's Forest Inventory - 1976).

Loss of anticipated growth because of interference by the pest with growth processes is another, although less obvious, effect on the forest. Data on growth losses in Nova Scotia resulting from moderate or severe defoliation by spruce budworm in the period 1977 - 1981 follow.

Year	Growth loss in fir and spruce (m3)
1977	1593
1978	1072
1979	1021
1980	1389
1981	1099
1977 - 1981	6176
Average annual growth loss	1235

Source: FIDS depletion estimates for CFS Nationals & Forestry Statistics approved by N.S. Land Forests.

(b) Spruce beetle - Dendroctonus rufipennis

Spruce beetle populations started to build up after hurricanes in the 1950's had caused serious blow-downs. Now widespread in Nova Scotia, economic losses by this insect are considerable.

Year	Volume loss to spruce beetle (m3)
1977	366 700
1978	502 900
1979	671 600
1980	456 600
1981	516 100
1977 - 1981	2513 900
Average annual spruce mortality	502 800

Source: FIDS depletion estimates for CFS National Forestry Statistics approved by N.S. Lands and Forests.

(c) Larch beetle - Dendroctonus simplex

Larch suffered from repeated severe defoliation by the larch sawfly during much of the 1960's and early 1970's. The larch beetle populations built up on weakened overmature trees and by 1977 tree mortality was common in Nova Scotia. Since then, population pressures forced the insect to attack trees of all but the smallest size. Volume losses of merchantable trees from the larch bettle are

Year	Volume loss to spruce beetle (m3)
1977	73 200
1978	109 300
1979	212 200
1980	283 700
1981	333 400
1977 - 1981	1 011 800
Average annual larch mortality	202 400

Source: FIDS depletion estimates for CFS National Forestry Statistics approved by N.S. Lands and Forests.

(d) Beech bark disease - Nectria coccinea var. faginata

Beech, once a valuable tree species in the forests of Nova Scotia has been rendered an almost useless weed species by this introduced pest. Now comprising only 1.8% of the Province's inventory, the trees, although containing 1.57 million m3 of wood, are in bad shape. In 1980 a survey found the situation as follows

Tree condition	Percent in class
Healthy	0.5
Cankered - lightly	48.3
Cankered - severely	42.1
Dead	9.1

Source: Forest Pest Conditions in the Maritimes in 1980, M-X-118 Information Report MFRC.

Assuming that the average dead tree falls after 10 years in an uneven aged beech stand the loss represents an average annual loss of 143 000 m3 to beech bark disease.

(e) Hypoxylon canker - Hypoxylon mammatum

A perennial disease of poplars, the fungus causes cankers that girdle the tree and kill it. Losses are due to mortality, growth loss, and indirectly to dead trees occupying forest space. The disease has an added importance in campgrounds, picnic sites, etc., where diseased trees pose a hazard to life and property. Losses to mortality are

Year	Volume loss to Hypoxylon canker (m3)
1977	15 800
1978	18 500
1979	15 800
1980	18 500
1981	15 800
1977 - 1981	84 400
Average annual poplar mortality to Hypoxylon canker	16 900

Source: FIDS depletion estimates for National Forestry Statistics approved by N.S. Lands and Forests.

(f) White pine blister rust - Cronartium ribicola

For many years the disease has discouraged foresters from considering white pine in plantation programs. Losses to the disease in merchantable forests are only a part of its importance.

Year	Volume loss to white pine blister rust (m3)
1977	14 000
1978	7 000
1979	14 100
1980	14 000
1981	14 100
1977-1981	63 200
Average annual mortality	12 600

Source: FIDS depletion estimates for National Forestry Statistics approved by N.S. Lands and Forests.

(g) Decays and culls

The presence and damage caused by hundreds of decay fungi are often noted only at harvest. The amount of decay is deducted from the wood volume in the log or if the decayed portion of the log warrants it, the entire log is 'culled'. Losses to these factors are

	Volume lost to decay and cull (m3)
Decay in conifers	264 100
Cull in conifers	369 700
Decay in hardwoods	282 100
Cull in hardwoods	282 100
Average annual loss	239 600

Source: FIDS depletion estimates for CFS National Forestry Statistics approved by N.S. Lands and Forests.

(h) Dutch elm disease - Ceratocystis ulmi

Although elm is not an important forest species its ravages are traditionally the concern of forestry departments throughout Canada. Infected trees die and unless they are removed they further the spread of Dutch elm disease through its vector the elm bark beetle. The removal of trees costs money, in 1980 alone the Nova Scotia Department of Lands and Forests contributed $50 000[1] to a shared cost program with municipalities. Because removed infected trees must be destroyed to retard the spread of the disease this cost is strictly "down the drain" money with no returns. The funds for this program come from the Provincial Treasury, a loss to a disease by taxpayers of Nova Scotia.

---

[1] Source: Nova Scotia Dept. Lands and Forests Annual Report for year ending March 31, 1981.

(i) Volume of tree mortality caused by forest pests in Nova Scotia (1977 - 1981)?

Organism	Average annual loss to mortality (m3)
Spruce budworm	3 148 060
Spruce beetle	502 800
Larch beetle	202 400
Decays and culls	239 600
Hypoxylon canker	16 900
Beech bark disease	14 300
White pine blister rust	12 600
Dutch elm disease	N/A
Other insects and diseases	Unknown
Average annual mortality from Nova Scotia forests due to forest pests (period 1977 - 1981)	4 136 600

?Includes mortality in stands of merchantable size only.

Number/
Numéro

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Environment Canada
Environnement Canada

Brief to the Nova Scotia Royal Commission on Forestry

Volume 2: Parks Canada
Canadian Wildlife Service
Environmental Protection Service

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This is the second volume of two in the Environment Canada Brief to the Nova Scotia Royal Commission on Forestry. It contains three sections:

SECTION 1: PARKS CANADA
SECTION 2: CANADIAN WILDLIFE SERVICE
SECTION 3: ENVIRONMENTAL PROTECTION SERVICE

Volume I of this brief contains the departmental overview and the submission prepared by the Canadian Forestry Service.

Environment Canada	Environement Canada
Parks Canada	Parcs Canada

DEPARTMENT OF ENVIRONMENT SUBMISSION TO THE NOVA SCOTIA ROYAL COMMISSION ON FORESTRY

SECTION 1 VOLUME III

PARKS CANADA

ATLANTIC REGIONAL OFFICE
HALIFAX, NOVA SCOTIA

FEBRUARY 1983

TABLE OF CONTENTS

Page

LIST OF TABLES iii

LIST OF FIGURES iv

APPENDICES v

LIST OF TABLES IN THE APPENDICES vi

LIST OF FIGURES IN THE APPENDICES vii

1.1. INTRODUCTION 1

1.2. PARKS CANADA MANDATE 4

  1.2.1 The National Park System 5

  1.2.2 International Role of National Parks 7

  1.2.3 The National Historic Park System 10

1.3. NATIONAL PARK MANAGEMENT 12

  1.3.1 The Park Management Plan 12

  1.3.2 Natural Resource Management in National Parks 15

    1.3.2.1 Resource Managment Constraints 15

    1.3.2.2 Resource Management Process 16

    1.3.2.3 Environmental Assessment and Review Process 19

    1.3.2.4 Resource Management Research Implications 19

      1.3.2.4.1 Research Opportunities 20

      1.3.2.4.2 Protection of Genetic Pools 20

      1.3.2.4.3 Environmental Benchmarks 24

1.4. NATIONAL HISTORIC PARK MANAGEMENT 25

1.5. SOCIO-ECONOMIC IMPACT OF NATIONAL PARKS IN NOVA SCOTIA 26

  1.5.1 Income Benefits 26

  1.5.2 Employment Benefits 26

  1.5.3 Investment by Parks Canada 27

  1.5.4 Projected Visitor Expenditures 31

  1.5.5 Tourist Industry Benefits 31

  1.5.6 Local Recreational Benefits 32

  1.5.7 Summary 32

1.6. SUMMARY 34

Page

1.7 RECOMMENDATIONS 37

Heritage Protection 37

Resource Management 40

Research 43

Forest Land Recreation 44

Future Liaison with the Forest Industries 46

1.8 LITERATURE CITED 47

LIST OF TABLES

Page

TABLE 1.1 Employment Generated by Parks (1981) 27

TABLE 1.2 Investment by Parks Canada From 1972/73 to 1981/82 28

TABLE 1.3 Projected Expenditures by Parks Canada 1981/82 to 1987/88 28

TABLE 1.4 Total of Local Direct and Indirect Income Benefits 1981 29

TABLE 1.5 Total of Provincial Direct and Indirect Income Benefits 1981 29

TABLE 1.6 Percentage of In Province to Out of Province Visitors 1981 30

TABLE 1.7 Projected Income Benefits for Kejimkujik, Cape Breton Highlands and Louisbourg for 1982 to 1987 31

LIST OF FIGURES

Page

FIGURE 1.1 National Park Natural Regions 6

FIGURE 1.2 National Parks of Canada 8

FIGURE 1.3 Natural Resource Management Process 17

APPENDICES

Page

1. PARKS CANADA'S ATLANTIC REGION ORGANIZATION 49
    1.1 Atlantic Regional Office Organization 49
    1.2 National Parks Organization 52
2. NATIONAL PARKS IN NOVA SCOTIA 54
    2.1 Cape Breton Highlands National Park 54
        2.1.1 Historic Background 54
        2.1.2 Physical Background and Park Facilities 56
            2.1.2.1 Geographical Location and Access 56
            2.1.2.2 Topography 58
            2.1.2.3 Climate 60
            2.1.2.4 Vegetation 62
            2.1.2.5 Fauna 66
            2.1.2.6 Park Facilities and Services 67

        2.1.3 Park Staff Organization 67
        2.1.4 Natural Resource Conservation 67
            1.6.1.4.1 Basic Natural Resource Inventory 68
            1.6.1.4.2 Resource Management Studies 73
            1.6.1.4.3 Resource Description and Analysis 75
            1.6.1.4.4 Natural Resource Monitoring Program ... 75
    2.2 Kejimkujik National Park 76
        2.2.1 Historical Background 76
        2.2.2 Physical Background and Park Facilities 76
            2.2.2.1 Geographical Location and Access 76
            2.2.2.2 Topography 78
            2.2.2.3 Climate 81
            2.2.2.4 Vegetation 82
            2.2.2.5 Fauna 85
            2.2.2.6 Park Facilities and Services 85

Page

2.2.3 Park Staff Organization 86
2.2.4 Natural Resource Conservation 87
    2.2.4.1 Basic Natural Resource Inventory 88
    2.2.4.2 Resource Management Studies 89
    2.2.4.3 Resource Description and Analysis 90
    2.2.4.4 Park Conservation Plan 91
    2.2.4.5 Natural Resource Management Plans 91
    2.2.4.6 Natural Resource Monitoring Program ... 92

LIST OF TABLES IN THE APPENDICES

Page

TABLE 1 Percentage Occurrence of Landforms, Surficial Material Type and Surficial Material Drainage Class in Cape Breton Highlands National Park 60

TABLE 2 Tree Species Groups and Non-Forested Vegetation Types for Cape Breton Highlands National Park 60

LIST OF FIGURES IN THE APPENDICES

FIGURE 1 Location of National Parks in the Atlantic Region 50

FIGURE 2 Location of National Parks in Nova Scotia and Fortress of Louisbourg National Historic Park 55

FIGURE 3 Cape Breton Highlands National Park 57

FIGURE 4 Map of Cape Breton Highlands National Park Showing the Main Geological Features 59

FIGURE 5 Cape Breton Highlands National Park - Abundance of Vegetation Types 65

FIGURE 6 Cape Breton Highlands National Park - Land Regions 69

FIGURE 7 Kejimkujik National Park 77

FIGURE 8 Kejimkujik National Park - Bedrock Geology 79

FIGURE 9 Kejimkujik National Park - Landforms and Surficial Geology 80

FIGURE 10 Kejimkujik National Park - Forest Types 83

FIGURE 11 Kejimkujik National Park - Ground Vegetation Groups 84

1.1 INTRODUCTION

Parks Canada is entrusted with responsibility to protect for all time those places which are significant examples of Canada's natural and cultural heritage and also to encourage public understanding, appreciation and enjoyment of this heritage in ways which leave it unimpaired for future generations. Some of these places, like Cape Breton Highlands National Park, are known around the world as symbols of the natural beauty of Canada. Other places, like the reconstructed Fortress of Louisbourg, are living evidence of the history of our country and the achievements of our ancestors.

Each National Park, National Historic Park or Historic Canal is unique and Parks Canada acts as the trustee of a national inheritance. Its primary responsibility is to conserve, protect and interpret the resources which have been entrusted to it, including natural and historic resources, wildlife, flora, geological features and artifacts.

Three Parks Canada properties in Nova Scotia have large land bases. Together, Cape Breton Highlands National Park, Kejimkujik National Park and Fortress of Louisbourg National Historic Park occupy 2.5 per cent of the province's land area. Each of the two national parks protects a portion of one of the natural regions of Canada with its associated physical and biological resources. The Fortress of Louisbourg protects both the reconstructed 18th century imperial French fortress and the lands associated with its siege and destruction.

Land management within these three parks differs markedly from most land management practices elsewhere in the province where effort is directed toward modifying or controlling nature, producing crops or extracting natural resources. Management of the park land is directed toward protecting the natural heritage by maintaining the physical environment in as natural a state as possible. In instances where active resource management is necessary in National Parks, techniques used must duplicate natural processes as closely as is practical.

Dedication of park land to this form of management has direct benefits to the forest industry. Parks become natural laboratories where ecological processes can be studied and understood. The lessons learned can often by applied outside parks at significant cost benefits. Parks help protect the genetic diversity of our biological resources. Areas extirpated of a wildlife species have been restocked by animals originating in parks. Species of animals and plants, that may be considered "worthless" or "harmful" outside parks, provide stocks for new products such as drugs and new sources of genetic material as we enter what has often been termed the second industrial revolution, biological engineering. Foresters, in increasing numbers, are looking at park trees that have had to evolve and grow in the absence of active management, for characteristics which provide them with superior genetics of growth rates or insect and disease resistance.

To many Nova Scotians and visitors, Parks Canada properties provide an opportunity to view their heritage or roots while also enjoying themselves. More than 657,000 visitors made use of Parks Canada's two National Parks in Nova Scotia during 1981. In addition, more than one and one-half million visits were recorded at Parks Canada's other properties including the Fortress of Louisbourg that year. Park facilities provide not only outdoor recreational opportunities such as canoe routes, campsites, beaches and cross country ski trails, but also an extensive interpretive program whose major function is to enhance the understanding of Canada's national and historic heritage.

Indirectly and directly these same properties generate considerable economic activity. Parks Canada spent directly in excess of $25 million in 1981 in Nova Scotia developing and operating them, but more significant are the monies generated indirectly by tourism in the province. The Government of Nova Scotia estimated non resident tourists spent in excess of 160 million dollars in Nova Scotia during 1981.

The objective of this presentation is to describe Parks Canada's purpose, organization and natural resource management practices implemented within the province's two national parks, and, to identify benefits offered to both resident and visitor by Nova Scotia's National Parks. A discussion of the impact of Parks Canada's operations on the provincial economy is also provided.

The appendices provide information on the application of policy and practices with respect to the management of Nova Scotia's two national parks and information regarding the Parks Canada organization structure in Nova Scotia.

1.2. PARKS CANADA MANDATE

The Parks Canada program is based on the conviction that places of natural and cultural significance constitute a national inheritance which should be protected. Since 1885, when the federal government set aside a ten square mile area of the Rocky Mountains, including cave and basin Hot Springs at Banff, federal policy has affirmed that such outstanding scenic resources should be publicly owned. The Rocky Mountains Parks Act of 1887 stated that the area was reserved as "a public park and pleasure ground for the benefit, advantage and enjoyment of the people of Canada.

In 1917, Fort Anne became the first National Historic Park when it was transferred from the jurisdiction of the Department of the Militia to the Dominion Parks Branch. In 1919, the federal government set up the Historic Sites and Monuments Board of Canada to advise the Minister concerning the national historic significance of persons, places or events. Since then, the federal government has administered historic and national parks as a single program emphasizing the common themes of national inheritance and public ownership.

In 1930, Parliament approved the National Parks Act. The Act provided legislative protection for national park lands and clarified that these places were to be used by the public so as to leave them unimpaired.

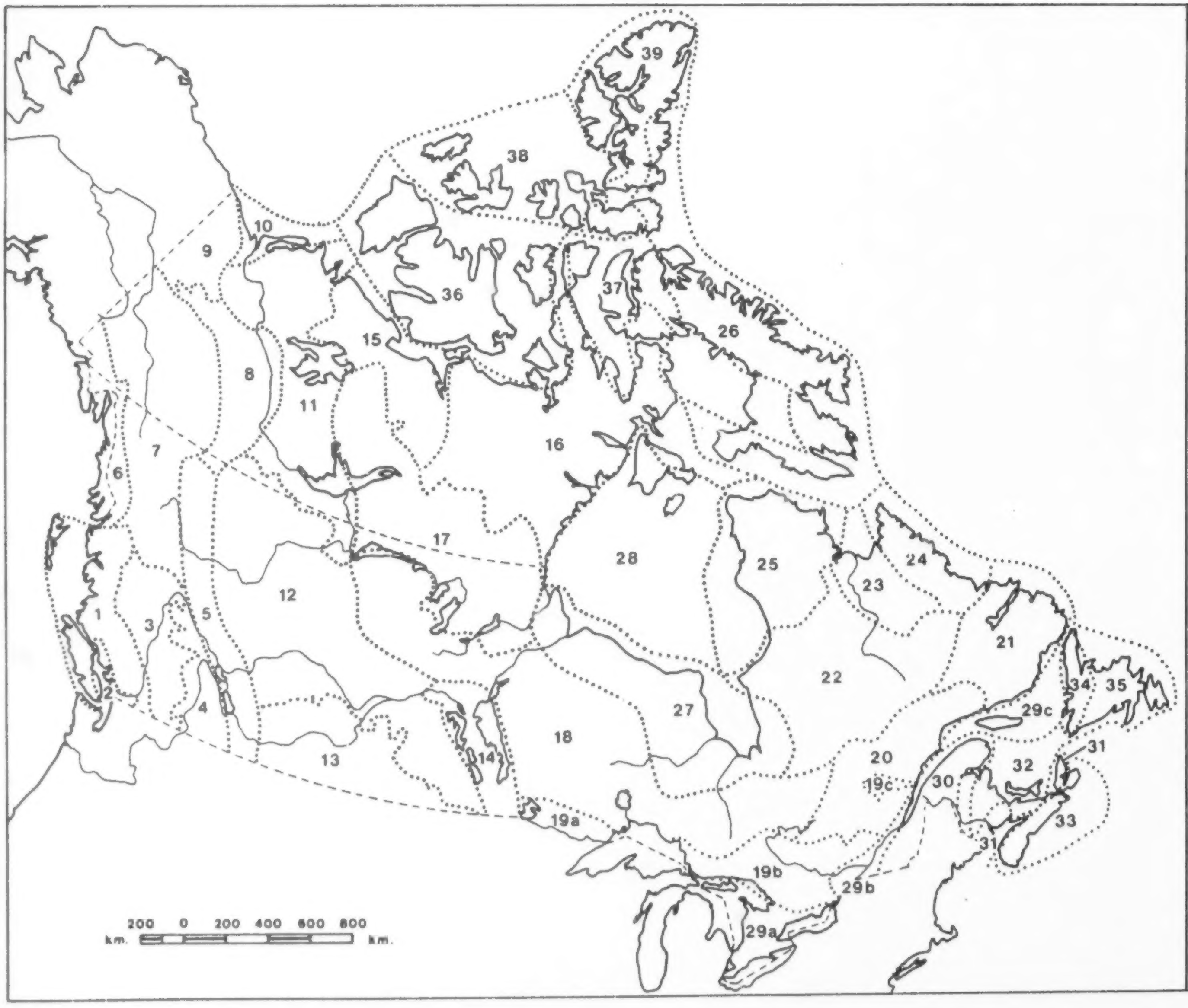
Section 4 of the 1930 Act stated: "The Parks are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to the provisions of this Act and the Regulations, and such Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations."

In 1953, the Historic Sites and Monuments Act was passed. This Act formally established the Historic Sites and Monuments Board as an advisory body to the Minister and gave the Minister statutory responsibility for developing and implementing a national program commemorating persons, places and events of prime national, historic and prehistoric interest.

In the 1960's, Canadians became more aware of their natural environment and developed a renewed interest in their history. The number of visitors to national and historic parks increased sharply leading to a growing concern about park protection and appropriate use. As a result, policies were prepared and issued for national parks in 1964 and national historic sites in 1967. These policies reflected changing times; greater emphasis was placed on protection of natural and historic resources, interpretation and educational activities, and professional planning. The policies were further updated in 1979. The policies for all the various activities of the Parks Canada Program are integrated within this update.

1.2.1 The National Park System

National parks are intended to protect representative examples of the diversity of Canada's landscape and marine areas for the benefit of present and future generations. To this end, Parks Canada has divided Canada into 48 natural regions, of which 39 are terrestrial and 9 are marine. Each of these natural regions should be represented in the system of national parks. In order to achieve this goal, certain natural areas are identified within each natural region, which include the greatest diversity of natural themes (biologic, geologic, physiographic, geographic and oceanographic) and which are therefore representative of the natural region. These areas are referred to as "representative natural areas of Canadian significance". Potential national parks are selected from among the representative natural areas of Canadian significance. Figure No. 1.1 provides the boundaries of the 39 terrestrial regions.



NATIONAL PARK NATURAL REGIONS

1. Pacific Coast Mountains
2. Strait of Georgia Lowlands
3. Interior Dry Plateau
4. Columbia Mountains
5. Rocky Mountains
6. Northern Coast Mountains
7. Northern Interior Plateaux and Mountains
8. Mackenzie Mountains
9. Northern Yukon Region
10. Mackenzie Delta
11. Northern Boreal Plains
12. Southern Boreal Plains and Plateaux
13. Prairie Grasslands
14. Manitoba Lowlands
15. Tundra Hills
16. Central Tundra Region
17. Northwestern Boreal Uplands
18. Central Boreal Uplands
19. St. Lawrence Precambrian Region
    (a) West Great Lakes
    (b) Central Great Lakes
    (c) East Great Lakes
20. Laurentian Boreal Highlands
21. East Coast Boreal Region
22. Boreal Lake Plateau
23. Whale River Region
24. Northern Labrador Mountains
25. Ungava Tundra Plateau
26. Northern Davis Region
27. Hudson-James Lowlands
28. Southampton Plain
29. (a) West St. Lawrence Lowland
    (b) Central St. Lawrence Lowland
    (c) East St. Lawrence Lowland
30. Notre Dame - Megantic Mountains
31. Maritime Acadian Highlands
32. Maritime Plain
33. Atlantic Coast Uplands
34. Western Newfoundland Island Highlands
35. Eastern Newfoundland Island Atlantic Region
36. Western Arctic Lowlands
37. Eastern Arctic Lowlands
38. Western High Arctic Region
39. Eastern High Arctic Glacier Region

Figure 1

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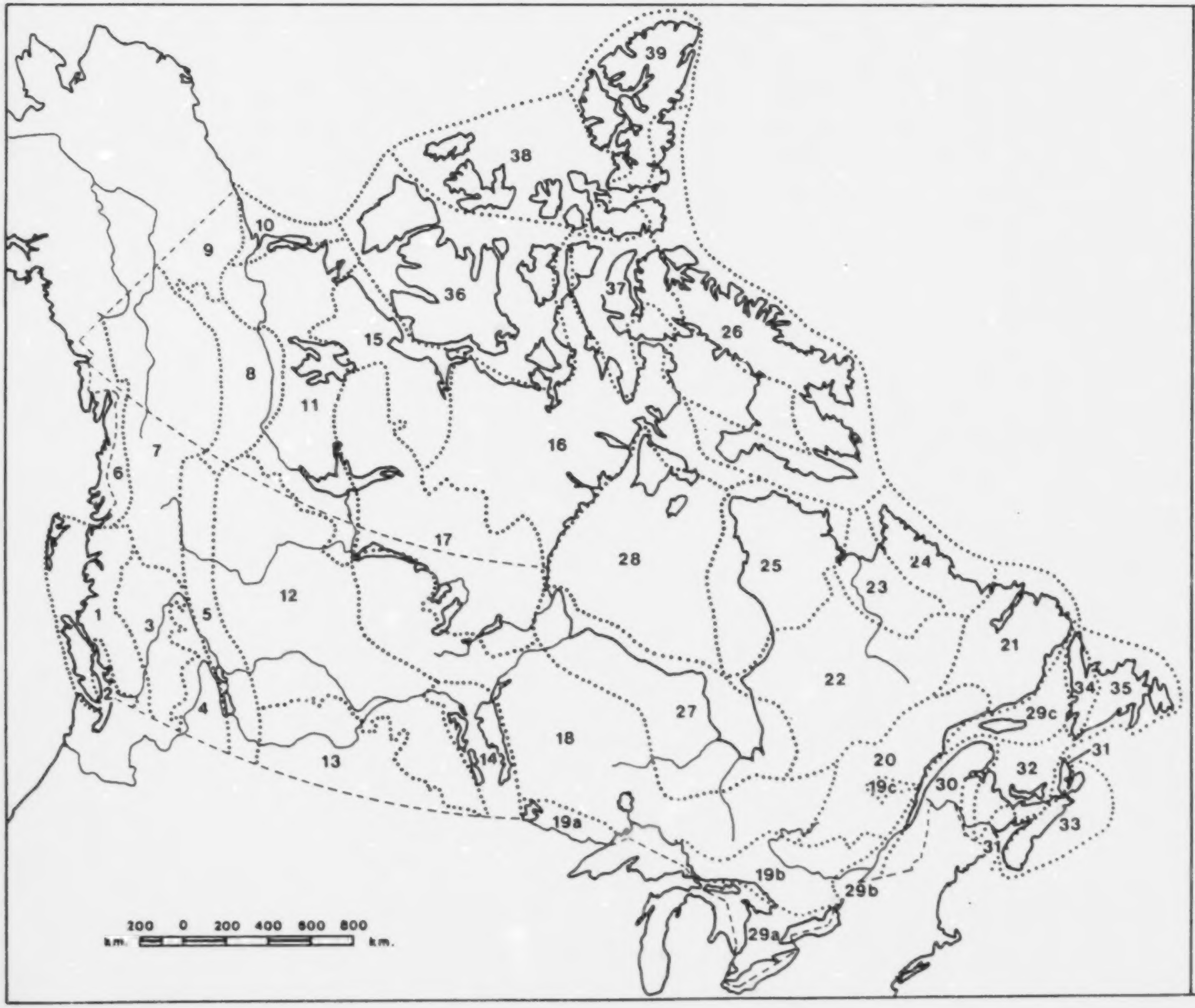

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39. Eastern High Arctic Glacier Region

Figure 1

The first national park in Canada was established in 1885 to protect the newly discovered Banff Hot Springs for public use. The national park system has grown since that time to now cover 1.3 per cent of Canada's land mass, including areas in each province and territory. Figure No. 1.2 shows the locations of the 29 national parks presently within the system.

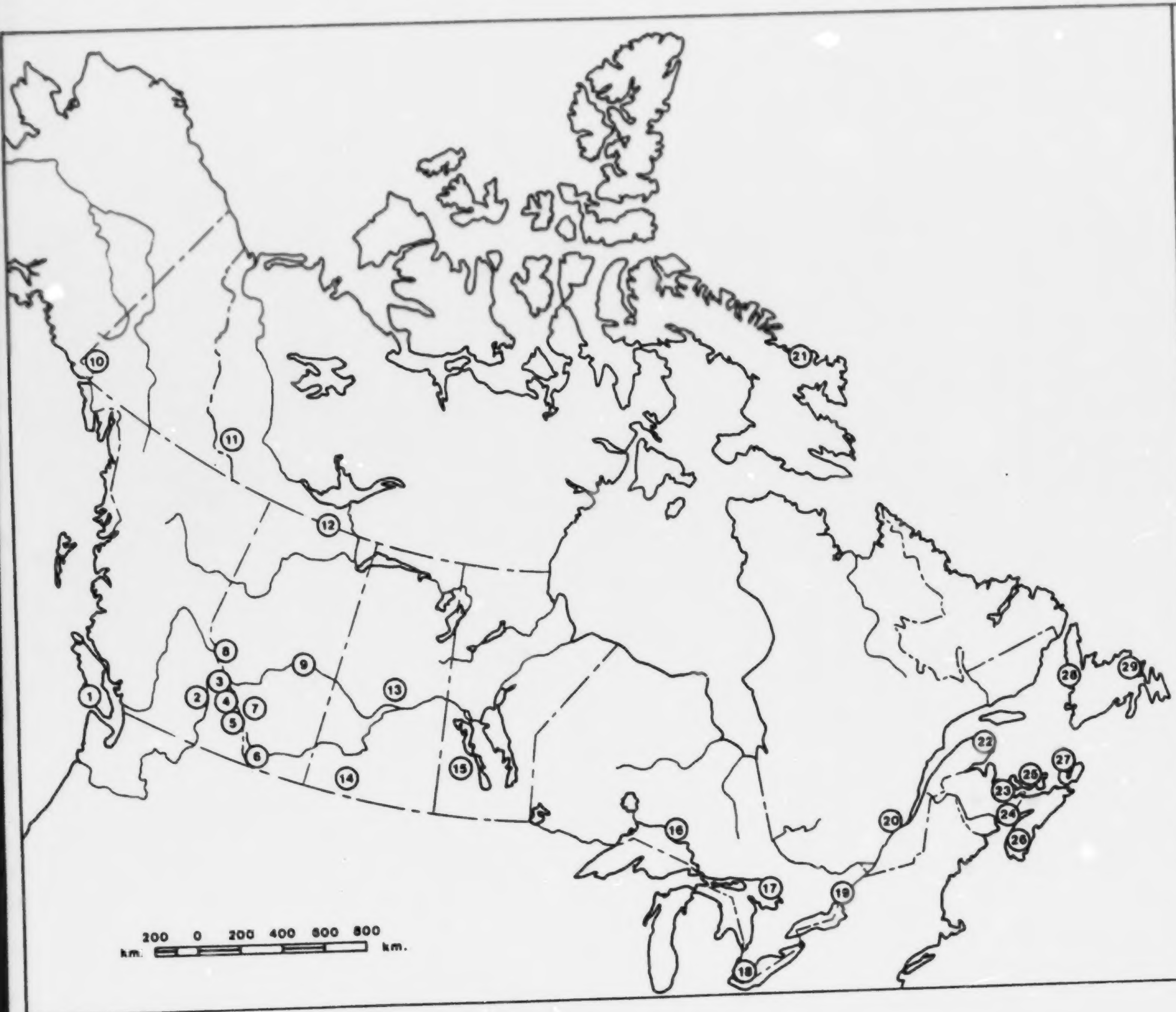
1.2.2 International Role of National Parks

While Parks Canada's properties fulfill the national responsibility of protecting and presenting Canada's heritage, there is a similar international onus for the protection and preservation of the world's natural and cultural heritage. National Park management must meet the standards established by International Union for the Conservation of Nature and Natural Resources. This International Union requires that national parks:

i) provide a status of general protection;
ii) be of a size in excess of a specified minimum; and
iii) ensure that protected status is adequately maintained.

The International Union further defines a national park as:

> "...a relatively large area: 1) where one or several ecosystems are not materially altered by human exploitation and occupation, where plant and animal species, geomorphological sites and habitats are of special scientific, educative and recreative interest or which contains a natural landscape of great beauty; and 2) where the highest competent authority of the country has taken steps to prevent or eliminate as soon as possible exploitation or occupation in the whole area and to enforce



National Parks of Canada

1	Pacific Rim
2	Mount Revelstoke
3	Glacier
4	Yoho
5	Kootenay
6	Waterton Lakes
7	Banff
8	Jasper
9	Elk Island
10	Kluane
11	Nahanni
12	Wood Buffalo
13	Prince Albert
14	Grasslands
15	Riding Mountain
16	Pukaskwa
17	Georgian Bay Islands
18	Point Pelee
19	St. Lawrence Islands
20	La Mauricie
21	Auyuittuq
22	Forillon
23	Kouchibouguac
24	Fundy
25	Prince Edward Island
26	Kejimkujik
27	Cape Breton Highlands
28	Gros Morne
29	Terra Nova

Figure 2

> effectively the respect of ecological, geomorphological or aesthetic features, which have led to its establishment; and 3) where visitors are allowed to enter, under special conditions, for inspirational, educative, cultural and recreative purposes."

In general, exploitation of natural resources are prohibited in any area which is to be identified as a national park. Exploitation, in this sense, is considered to include the removal of mineral resources, timber and other vegetation, and animal life, or the development of dams or other structures for irrigation or hydroelectric power. The International Union for the Conservation of Nature and National Resources has recently prepared a world strategy for the conservation and management of the earth's biosphere. In October 1981, the Federal Department of the Environment endorsed the World Conservaton Strategy for application in Canada.

The World Conservation Strategy has set three main objectives for living resource conservation. Parks Canada plays a role in two.

i) to maintain essential ecological processes and life-support systems;

ii) to preserve genetic diversity.

Environment Canada has assigned Parks Canada the lead for the tenth recommendation of the application of the strategy to Canada. "The Department of the Environment implements its strategy, in cooperation with provincial and territorial governments, to complete the National Park System giving priority to the protection and conservation of the selected areas which are not now represented in the system and where the threats from development are greatest."

In addition to membership in the International Union for the Conservation of Nature and Natural Resources, many nations adopted the "International Biological Program" of UNESCO to study the biological productivity of the earth and relate this to human adaptability and welfare. The Conservation of Terrestrial Communities section of the program is an international effort to preserve samples of the world's ecosystems for present and future biological research, as datum points by which to measure man-made changes to ecosystems, and for educational and demonstration purposes. In 1974, sixty-nine sites in Nova Scotia were recommended for identification as IBP-CT Ecological Reserves. Of the 19,885 hectares involved in these sites, over 8,000 hectares were located within national park boundaries.

1.2.3 The National Historic Park System

National historic parks are the means by which outstanding historic resources of importance to all Canadians can be protected by the federal government and made accessible to the public in their original location and in an authentic setting. Three factors distinguish a national historic park:

- national historic significance;
- protection and interpretation at the original place and in an authentic setting; and
- establishment, protection, interpretation and management by the federal government.

Canada's national historic park system began in 1917 with the establishment of Fort Anne as a national historic park. Since then, many other national historic parks have been developed, particularly in the 1960's and 1970's, representing a variety of historical themes in locations across Canada.

Public interest in our history is evident from the large numbers of people who visit Canada's national historic parks each year. Lower Fort Garry, near Winnipeg, the Fortress of Louisbourg in Cape Breton, Dawson City in the Yukon, Fort Langley in British Columbia, Quebec City Walls and Gates and the Halifax Citadel are well-known examples of national historic parks.

There are many benefits derived from national historic parks. They serve as tangible and enduring reminders of the human heritage of Canada, and indicators of the achievements and lifestyle of our ancestors. By visiting the parks, Canadians can better understand and appreciate their past. Many people gain satisfaction from knowing that future generations will also be able to visit these areas. A growing number of Canadians are discovering that a visit to a national historic park is a pleasant and rewarding way to spend leisure time. The increased visitation, not only by Canadians, but by visitors from other countries, results in increased employment possibilities and tourism industry development in areas adjacent to national historic parks.

1.3. NATIONAL PARK MANAGEMENT

National parks are managed so as to achieve established objectives. A sophisticated process is utilized in their mangement which has been designed to be sensitive to resource values, the needs of the park visitor and the community in which the park is located. A basic requirement in the process is a Park Management Plan.

1.3.1 The Park Management Plan

A Park Management Plan is defined as the guide by which Parks Canada manages the resources and uses of a national park. It contains the management objectives and the means and strategies for achieving them. The management plan is not an end in itself, but rather it constitutes a framework within which subsequent management, implementation and detailed planning will take place. Thus, the level of detail in the plan is confined to the definition of the type, character, locale of developments, and the provision of guidelines for resource management, interpretation and visitor use. The plan, in effect, is an expression of policy at the park level. A public document, it informs the public of opportunities which are available and of the degree of protection necessary for different zones within the park.

Several important products are developed or refined and receive approval during management plan preparation. These include the park purpose and objective statement, park objectives and park zoning plan.

The park purpose and objectives statement describes the park, its resources, facilities, program and socio-economic considerations. It specifies the purpose of the national park in its natural region, while outlining specific heritage values the national park protects. It specifies the park's purpose for public understanding and enjoyment and outlines the park's natural history and cultural resources. It then provides directional objectives to be met by the park plan based upon the needs derived from the park purpose.

Park zoning is one of the most important tools for the planning, development and management of national parks. The national parks zoning system is a resource-based approach by which land and water areas of a national park are classified according to their need for protection and their capability to accommodate visitors. It provides a guide for the activities of both visitors and managers within a national park. It assists in managing the dichotomy between use and protection while providing a means to ensure that the majority of national park lands and their living resources are protected in a wilderness state with a minimum of man-made facilities. Zones encompassing visitor activities and supporting facilities and services occupy no more a relatively small proportion of lands in a national park.

Parks Canada zoning consists of the following five zones:
Zone I - Special Preservation: Specific areas or features which deserve special protection because they contain or support unique, rare or endangered features or the best examples of natural features. Access and use will be strictly controlled or may be prohibited altogether. No motorized access or man-made facilities will be permitted.

Zone II - Wilderness: Extensive areas, which are good representations of each of the natural history themes of the park maintained in a wilderness state. Only certain activities requiring limited primitive visitor facilities appropriate to a wilderness experience will be allowed.

Limits will be placed on numbers of users. Motorized access is not permitted. Management actions ensure that visitors are dispersed.

Zone III - Natural Environment: Areas that are maintained as natural environments and which can sustain, with a minimum of impairment, a selected range of low-density outdoor activities with a minimum of related facilities. Non-motorized access is preferred. Access by public transit is sometimes permitted. Controlled access by private vehicles is only permitted where it has traditionally been allowed in the past.

Zone IV - Outdoor Recreation: Limited areas that can accommodate a broad range of education, outdoor recreation opportunities and related facilities in ways that respect the natural landscape and that are safe and convenient. Motorized access is commonplace.

Zone V - Park Services: Towns and visitor centres in certain existing national parks which contain a concentration of visitor services and support facilities as well as park administration functions.

An important aspect in preparing the management plan is the involvement of the public. Throughout plan preparation, Parks Canada regularly consults the public for their ideas and to obtain reactions to management proposals.

1.3.2 Natural Resource Management in National Parks

Land management within national parks differs markedly from that of most other lands, where effort is directed toward modifying or controlling nature, producing crops or extracting natural resources. Within national parks, effort is directed towards protecting the resources by maintaining the physical environment in as natural a state as possible. This fact has far-reaching implications in that many concepts or ideas which are relevant or essential to the successful management of other lands have limited relevance to the management of national parks. Park Managers, therefore, exercise caution before any active manipulation of park resources is undertaken and preference is given to allowing natural processes to function unless they have been clearly altered or made inoperative by man-induced changes.

The management of national parks should not, however, be in isolation from the regions in which they are located. Few, if any, land uses, either within or outside national parks, can occur without there being both beneficial and detrimental effects on the surrounding lands. Cooperation with other land management agencies is therefore essential.

1.3.2.1 Resource Management Constraints

Natural resources within national parks are protected and managed with minimal interference to natural processes to ensure the perpetuation of naturally evolving land and water environments and their associated species. Manipulation of naturally occurring processes such as fire, insects and disease may take place only after monitoring has shown that:

i) there may be serious adverse effects on neighbouring lands; or
ii) public health or safety is threatened; or

iii) major park facilities are threatened; or

iv) natural processes have been altered by man and manipulation is required to restore the natural balance; or

v) a major natural control is absent from the park; or

vi) the continued existence of a plant or animal species, which is rare or endangered or which is critical to representation of the natural region, is threatened by a natural cause such as insects or disease; or

vii) the population of an animal species or stage of plant succession which has been prescribed in the objectives for a park, cannot be maintained by natural forces.

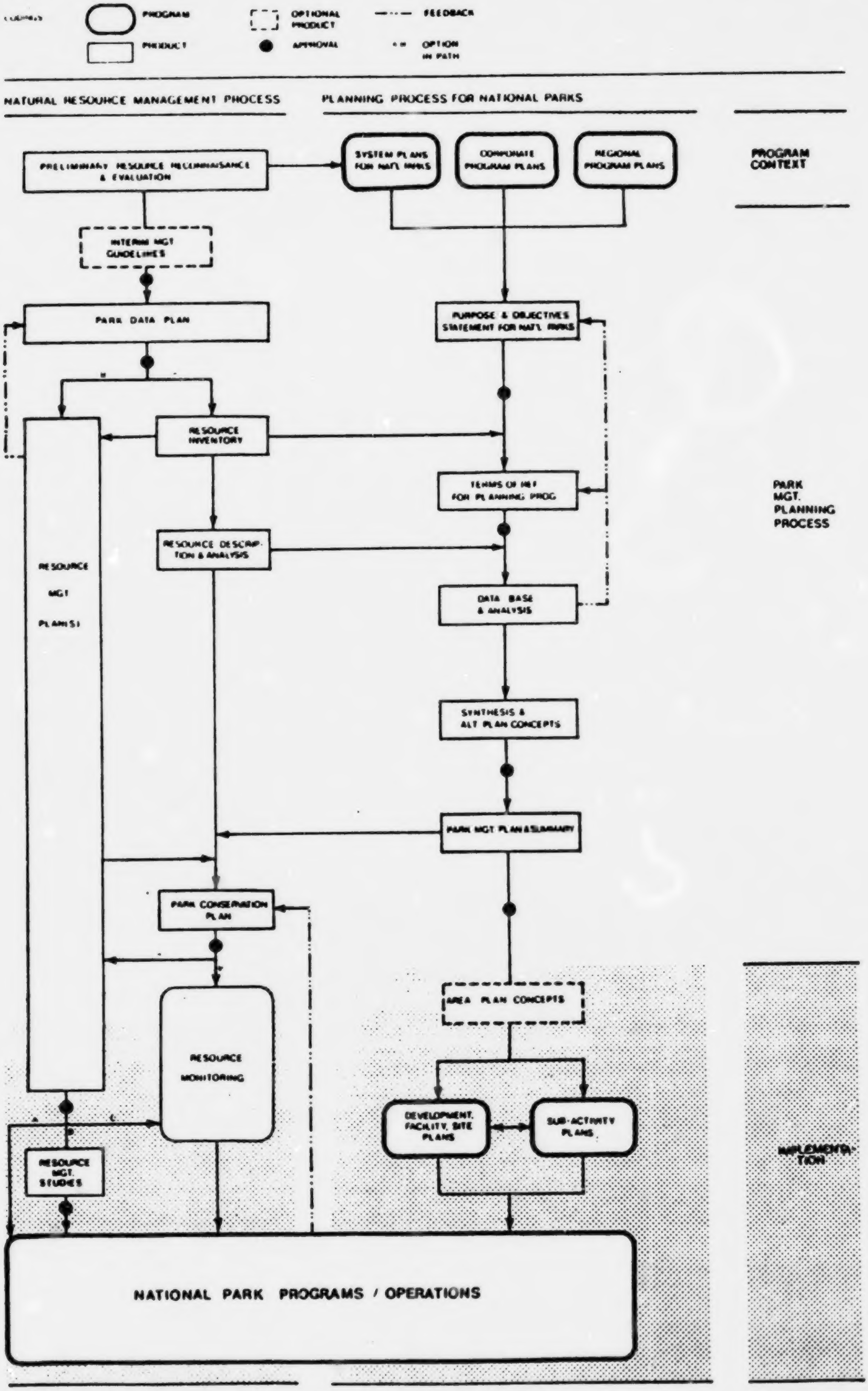
It follows that where active resource management is necessary, techniques used duplicate natural processes as closely as possible.

1.3.2.2. Resource Management Process

An internationally recognized process has been developed to manage natural resources in national parks in Canada. Standardized procedures ensure that the park resources are adequately understood; that objectives are consistent with park resource values; and that dollar and personnel resources are effectively allocated to protect and manage these natural resources. The steps from the time of park establishment are shown in Figure 1.3 and are as follows:

1 - Interim Management Guidelines: A preliminary set of operational guidelines to be utilized until detailed resource inventories are completed and a management plan is approved. These guidelines take into consideration the reason the park was established and the conditions in the agreement with the province or territory.

FIG. 3 NATURAL RESOURCE MANAGEMENT PROCESS AND PLANNING PROCESS FOR NATIONAL PARKS.


CODING
PROGRAM
PRODUCT
OPTIONAL PRODUCT
APPROVAL
FEEDBACK
OPTION IN PATH
NATURAL RESOURCE MANAGEMENT PROCESS
PLANNING PROCESS FOR NATIONAL PARKS
PRELIMINARY RESOURCE RECONNAISANCE & EVALUATION
SYSTEM PLANS FOR NAT'L PARKS
CORPORATE PROGRAM PLANS
REGIONAL PROGRAM PLANS
PROGRAM CONTEXT
INTERIM MGT GUIDELINES
PARK DATA PLAN
PURPOSE & OBJECTIVES STATEMENT FOR NAT'L PARKS
RESOURCE INVENTORY
TERMS OF REF FOR PLANNING PROG
PARK MGT. PLANNING PROCESS
RESOURCE MGT PLAN(S)
RESOURCE DESCRIPTION & ANALYSIS
DATA BASE & ANALYSIS
SYNTHESIS & ALT PLAN CONCEPTS
PARK MGT PLAN & SUMMARY
PARK CONSERVATION PLAN
AREA PLAN CONCEPTS
RESOURCE MONITORING
DEVELOPMENT, FACILITY, SITE PLANS
SUB-ACTIVITY PLANS
IMPLEMENTATION
RESOURCE MGT. STUDIES
NATIONAL PARK PROGRAMS / OPERATIONS

NOTE 1) EVALUATION & MONITORING occur at all stages of 'Park Mgt Planning Process' and 'Implementation'

2) 'Natural Res. Mgt. Process' is one of many inputs into the 'Planning Process For National Parks'

2 - Park Data Plan: A plan which manages the gathering of inventory data necessary to meet the projected management requirements of a national park.

3 - Resource Inventory: Inventories of all components of a park's natural and cultural resources. Parks Canada has utilized the system known as an Ecological Land Classification (Biophysical) to conduct its inventory of park resources. It classifies units of land, based on common characteristics of climate, parent material, surficial materials, soils, vegetation and water bodies.

4 - Resource Description and Analysis: This is a public document, which describes and evaluates the park's resources and outlines opportunities and constraints for use. It develops specific proposals for resource management objectives and as such will constitute the primary resource management contribution to the park management planning process.

5 - The Park Conservation Plan: The plan identifies resource concerns or problems; develops objectives; designates a course of action in problem solving; ranks the various resource management actions; and determines the resources necessary to implement these actions. A dynamic management tool, the Park Conservation Plan is updated annually.

6 - Resource Management Studies: Specific information is gathered by resource management studies that is not included in existing park data and which is identified by the Park Conservation Plan as required to solve natural resource concerns.

7 - Resource Management Plans: Plans that detail courses of action including responsibilities and procedures whereby resource concerns or problems identified in the Park Conservation Plan are resolved.

8 - Resource Monitoring: Resource monitoring is an organized surveillance of identified natural resources carried out in order to:

(a) determine the success and adequacy of courses of action specified in Resource Management Plans;

(b) monitor the environmental effects of park developments to determine the success of any impact mitigating measures; and to

(c) enhance the ability of park managers to identify and correct undesirable trends and problems not addressed in Resource Management Plans or as the result of mitigating the impact of a development.

1.3.2.3 Environmental Assessment and Review Process

All developments, plans and management activities occuring on Parks Canada lands, including those proposed by agencies other than Parks Canada, are subject to an assessment and review process which ensure that the environmental implications are fully considered in decision-making. The process used for environmental assessment is consistent with the Federal Environmental Assessment and Review Process, and all products of the environmental assessment and review process including screening reports, initial environmental evaluations and environmental impact statements are available for public review.

1.3.2.4 Resource Management Research Implications

National Park Policy provides for scientific research to take place within parks. It recognizes that, although such research may not be essential for park management, it may expand man's fund of knowledge and enable parks to serve as benchmarks for ecological research and for studies of the effects of modern technology on lands outside park boundaries.

1.3.2.4.1 Research Opportunities

National parks provide opportunities for research or monitoring activities in areas that are not being disturbed or modified by man. Some research can be effective only in such natural areas. For instance, wildlife researchers need to study faunal behaviour, population dynamics and predator-prey relationships in a natural situation. This baseline information permits development of management strategies for populations outside undisturbed ecosystems.

Foresters also have utilized Canadian national parks to acquire basic research data on natural forest conditions. This information is used not only to compare "managed" forests with natural conditions, but also to provide insights into management options using ecological approaches, such as biological controls. Recently, a team of foresters from Japan travelled to Canada to gather data on growth characteristics of even aged stands in natural environmental conditions.

Parks Canada currently cooperates with the research efforts of other government and non-government organizations and encourages active cooperation on research programs which will be beneficial. To facilitate this, cooperative agreements with the Canadian Wildlife Service and the Canadian Forestry Service have been signed to streamline administrative and financial procedures when conducting projects.

1.3.2.4.2 Protection of Genetic Pools

The evolution of plant and animal species is partially a product of a rather "hit and miss" process called selection. In the natural world, selection works on the principle that it is probable that the most biologically fit individuals will survive to pass on their genetic characteristics while it is probable that the least fit will not. This simple process has led to the development of the vast number of life forms presently found on earth, all the most suitable for the environment in which they are found. Man is capable of using selection, both destructively and creatively. This is suspected in past and present forest management practices. In the past, loggers selectively cut the best stands of the "desirable" species, with little regard for the ecological consequences of losing this genetic stock for future regeneration. Often, only trees of low quality were left.

The early interest in Nova Scotia's forest resources was directed at quality specimens of specific species such as white pine (Pinus strobus) which were utilized for spars and masts by the Royal Navy. By the early 19th century, pine stands had virtually vanished from several areas in Nova Scotia. The harvesting of eastern white cedar (Thuja occidentalis) and tamarack (Larix laricina) to be used for ship knees during the 1840's and 1850's seriously depleted or threatened these stands. (Fergusson 1955)* "The high value of Red Oak for boat building and export (particularly for rum barrels to St. Pierre & Miquelon) resulted in the near elimination of this species from the forests of the Grande Anse valley." (O'Brien, M., J. Pleau 1978).

Today's silviculturist is concerned with selecting the "best" or plus trees for future genetic stock improvement. These have desirable height and diameter growth characteristics and morphology. Trees are also selected for insect and disease resistance. This artifical genetic selection process is dependent upon the availability of suitable trees.

The desirable traits exhibited by such trees have developed over the years in natural woodlands under the pressures of natural selection. Coincidentally, these traits have increased the probability of dominance by such trees in natural woodland. They out-compete for light, water and nutrients, generally by more rapid growth, and are most resistant to natural pressures, such as insects and disease, and have adapted to recurrent disturbances such as fires. Though natural woodlands are reservoirs for genetic characteristics which may be desirable for future silvicultural activities, they also represent a laboratory in which plant and animal species test various genetic combinations to new pressures that will evolve in the environment.

Without such concurrent activity under natural conditions there is a danger of banking on only the genetic combinations contained in nursey stock to deal with climatic changes, newly developing insect pests, air and water pollutants or depleting soil fertility.

Furthermore, to truly have natural woodlands act in this capacity it is not enough to designate but one area. A system of areas capturing environmental variability can stimulate the development and maintain the maximum number of different genetic variables. A national park system such as Canada's strives to assist the fulfillment of this requirement.

The advances by the agricultural industry utilization of genetic stock from around the world are impressive. Very few of the grasses that we see in our pastures are the product of only one genetic strain. In fact, many of our grasses and the vegetables we eat daily are the product of careful selection of genetic characteristics from around the world.

Some characteristics found only in the original "wild" stock are no longer found in these domestic strains. A major concern of agriculturalists is the potential loss of the wildstock and their inherent genetic traits, qualities that may be sought for in the future. Seed banks and various biological reserves to protect this potential agricultural stock is considered a high priority by international authorities. Likewise, the pharmaceutical and pest control industries are concerned with protecting the maximum genetic diversity to be applied to future technology. This is particularly important as only a very small percentage of the world's existing plant life have been investigated as to their potential usefulness to mankind in this regard.

Silviculture is following the lead taken by agriculture as obviously the process is slower because of generation cycles. Nevertheless, lessons learned by the agricultural industry apply. Silviculturists also have a stake in protecting natural stocks and the evolution of natural stocks in reserves such as National Parks.

In the future genetic engineering will greatly multiply the benefits to man by the production of new technologies, tools and products. The technology, however, is limited by the variety of individual genes protected and thus made available within the world's gene bank.

National Park forests' potential for providing genetic materials has not been extensively utilized in the past despite Parks Canada's recognition that this activity can be compatible with resource protection. In the future, the gene pools protected in parks will become invaluable to silviculture.

1.3.2.4.3 Environmental Benchmarks

The Kejimkujik Calibrated Watersheds are good examples of an extensive benchmark data gathering program carried out in a national park. This program related to acid rain research, measures baseline environmental parameters with the purpose of monitoring changes in these parameters over time to determine if such changes are generated by deposition of acids from local and distant sources. Experts from the federal government, universities and consulting firms with cooperation from personnel from the Nova Scotian provincial government have looked at subjects as diverse as water quality, the ionic content of rain falling through forest canopies, the distribution of various fish and amphibians and the impact that acids and neutralizing agents have on a variety of plants and animals.

Kejimkujik is one of five such acid rain monitoring locations in Canada and was chosen not only because of biological and physical characteristics, but also because it will be protected from other disturbances over a long time period. Only this protection can ensure consistent and comparable data which will help monitor what many feel is the most significant environmental problem of this decade.

National parks will be looked upon increasingly as benchmarks of the impact that man's activity has on natural ecosystems.

1.4. NATIONAL HISTORIC PARK MANAGEMENT

National historic parks are established to protect historic resources and to encourage public understanding, appreciation and enjoyment of these resources. Protection of these historic resources takes priority over the protection of natural resources. The natural resources of parks which have large land units, such as the Fortress of Louisbourg, are managed although the objectives generally differ markedly from those for National Parks.

Natural features within national historic parks are protected:

i) when they are of scientific, ecological or esthetic significance and/or interpretive interest to the public; and

ii) when serious disturbance or damage to the authentic historic resources and environment being protected will not occur.

Encroaching vegetation or the erosion by sea or rivers could seriously damage or destroy historic resources protected in historic parks. Protecting the historic resources would take precedence in these situations. Natural resources and lands are also managed surrounding national historic parks to prevent intrusions into the historic scene.

Natural resource management has been initiated at the Fortress of Louisbourg. Due to its land base of 50.5 square kilometers, of which some 45 square kilometers are forested, it is the only historic park in Nova Scotia having a direct bearing on this presentation. An ecological land classification and both limnological and mammal inventories have been completed. Avifaunal inventories are progressing. A large clearing surrounding the reconstruction is being maintained to present a vista which would resemble the landscape that was cleared for firewood during the 18th century.

1.5. SOCIO-ECONOMIC IMPACT OF NATIONAL PARKS IN NOVA SCOTIA

1.5.1 Income Benefits

Significant measurable benefits in the form of income accrue to the local area and the Province as a result of the three parks' existence in Nova Scotia. These benefits result from direct spending by Parks Canada on wages, salaries and the purchase of goods and services. They also include expenditures by park visitors. These direct expenditures also induce indirect spending. Indirect spending occurs when employment income created by the direct expenditures is respent on wages, salaries and goods and services. It is estimated for 1981 alone, the total income benefit accruing to the province amounted to nearly 22 million dollars. Perhaps more significantly, nearly 16 million dollars of the 22 million was spent in or around the local area of the parks or site.

It is worthy to note that nearly one-half of these expenditures were spent on the salaries and wages of the people hired to construct, maintain, and operate the sites and the associated businesses, which sell the goods and services required. The other 50% of accrued income results from the variety of expenditures made by site visitors for such things as souvenirs, groceries, fuel and accommodation. Tables 1.4 and 1.5 present the detailed estimates of the income benefits generated by the three sites.

1.5.2 Employment Benefits

The three parks considered are located in rural areas where employment opportunities are limited. The estimated 10.5 million dollars spent on wages and salaries for 1981 represent a significant contribution to the employment opportunities in the three areas. The Fortress of Louisbourg stands out as an example of Parks Canada's contribution to employment in depressed areas. In addition to preserving Louisbourg as a significant example of Canada's early history, the Fortress was also reconstructed to provide permanent employment and retraining for unemployed Cape Breton coal miners.

For fiscal year 1981-82, a total of 1,147 jobs was created attributable to the direct and indirect effects of the three parks. Direct employment represents the people hired by the Park for construction, operation, and maintenance purposes. Indirect employment represents jobs created in local businesses as a result of sales generated by the three sites. Table 1.1 indicates an estimated total of 657.7 indirect jobs was created during the 1981-82 fiscal year.

TABLE 1.1

Employment Generated by Parks (1981)

	Kejimkujik	Cape Breton Highlands	Fortress of Louisbourg	Total
Direct -Full-Time	26	60	96	182
-Full-time seasonal	41	126	141	308
Indirect	14.5	643	-	657.5
Total	81.5	829	237	1,147.5 jobs

*Studies have not been conducted to obtain this information

1.5.3 Investment by Parks Canada

Parks Canada's multi-million dollar investment into Nova Scotia's National Parks and National Historic Sites is an ongoing program aimed at protecting significant natural and cultural resources. Substantial benefits in terms of income, employment, recreation, and the preservation of heritage have been realized by Nova Scotians. Parks Canada has expended over 113 million dollars during the past ten years for Kejimkujik, Cape Breton Highlands and Louisbourg as shown in Table 1.2.

TABLE 1.2

Investment By Parks Canada From 1972/73 to 1981/82 (Thousands of 1981 Dollars)

	Kejimkujik	C.B.H.	Louisbourg	Total
Operation and Maintenance	9,793.7	24,753.6	34,712.4	69,259.7
Capital Projects	3,656.9	16,266.6	23,883.2	43,806.7
Total	$13,450.6	$41,020.2	$58,595.6	$113,066.4

Parks Canada's total expenditures in protecting and operating all its heritage properties in Nova Scotia exceeded 25 million dollars in 1981.

Expenditures by Parks Canda for these three areas during the next five-year period is estimated at about 70 million dollars as shown in Table 1.3.

TABLE 1.3

Projected Expenditures by Parks Canada 1981/82 To 87/88 (Thousands of 1981 Dollars)

	Kejimkujik	C.B.H.	Louisbourg	Total
Operation and Maintenance	3,900.0	9,610.0	14,575.0	28,085.0
Capital Projects	2,791.1	23,274.9	15,702.0	41,768.0
Total	$6,691.1	$32,884.9	$30,277.0	$69,853.0

This continued investment by Parks Canada ensures the employment, income, and recreational benefits enjoyed by the local area and province in the past will continue to be enjoyed in the future as well.

TABLE 1.4

Total of Local Direct and Indirect Income Benefits 1981
(Thousands of 1981 Dollars)

	Kejimkujik	Cape Breton Highlands	Fortress of Louisbourg	Total	Percentage Direct
Wages and Salaries	897.5	2,621.4	4,157.4	7,676.3	85%
Park Purchases	16.3	18.2	---*	34.5	57%
Visitor Purchases	187.2	7,708.9	1,337.4	9,233.5	76%
Total	$1,101.0	$10,348.5	$5,494.8	$16,944.3	

*Not Available

TABLE 1.5

Total of Provincial Direct and Indirect Income Benefits 1981
(Thousands of 1981 Dollars)

	Kejimkujik	Cape Breton Highlands	Fortress of Louisbourg	Total	Percentage Direct
Wages and Salaries	1,296.0	3,211.5	6,003.5	10,511.0	62%
Park Purchases	23.5	22.3	---*	45.8	62%
Visitor Purchases	270.4	9,444.3	1,638.8	11,353.5	62%
Total	$1,589.9	$12,678.1	$7,642.3	$21,910.3	

*Not Available

National Parks and Historic Sites are important components in the package of passive and active recreational opportunities, which attract non-residents to visit the province. Table 1.6 demonstrates just how important these parks are, showing, for example, that 76% of Cape Breton Highlands National Park visitors were non-Nova Scotians. In fact, the three parks together account for over 17% of the total number of out of province visitors to Nova Scotia.

TABLE 1.6

Percentage of In Province to Out of Province Visitors 1981

	Total Attendance 1981	Out of Province Visitor	% Out of Province
Kejimkujik N.P.	211,833	84,733	40
Cape Breton Highlands N.P.	467,937*	355,632	76
Fortress of Louisbourg N.H.P.	296,944**	216,769	73
Total % of Out of Province Visitors			67

* adjusted to reflect non-user visits, such as local residents driving through the park.

** 1980 figure. A change in counting procedures in 1981 has reduced the comparability of the 1981 attendance figure, therefore 1980 was used instead.

Table 1.6 shows that 657,134 visits were made by out of province tourists at the three parks. It is possible that the tourists will visit all three of the National Parks during their stay in Nova Scotia, thereby reducing this figure to no less than 200,000 visitors to the province, or about one-sixth of the total number of out of province visitors. It is evident from this analysis that Kejimkujik, Cape Breton Highlands, and Louisbourg are indeed major drawing forces to the multi-million dollar tourist industry in Nova Scotia.

1.5.4 Projected Visitor Expenditures

Associated with Parks Canada's five-year project of expenditures of nearly 70 million dollars at Kejimkujik, Cape Breton Highlands, and Louisbourg is the anticipated volume of visitors, which will provide continued economic benefits. By applying a conservative user forecast of a slow-to-no-growth in park visitors for the next five years, direct and indirect visitor expenditures have been estimated (Table 1.7). Direct and indirect sales for the three parks are nearly 80,472,400. dollars for the 1982-87 period.

TABLE 1.7
Projected Income Benefits for Kejimkujik,
Cape Breton Highlands and Louisbourg For 1982 To 1987
(Thousands of 1981 Dollars)

	Kejimkujik	C.B.H.	Louisbourg	Total	% Direct
Wages and Salaries	4,321.2	12,550.6	16,149.1	33,020.9	85
Park Purchases	81.5	91	---*	172.5	57
Visitor Purchases	964.4	39,476.4	6,789.0	47,229.	76
Total	$5,367.1	$52,118.0	$22,938.1	$80,422.4	

*Not Available

1.5.5 Tourist Industry Benefits

Tourism in all provinces of the country is seen as an important contribution to provincial economies. It is no different in Nova Scotia. In 1979, non-resident tourists spent some 128.8 million dollars and approximately 1,233,300 tourists stayed one or more nights in the province.

1.5.6 Local Recreational Benefits

To this point, the discussion has focused upon the economic benefits to Nova Scotia as a result of Kejimkujik and Cape Breton Highlands National Parks and Fortress of Louisbourg National Historic Park. The contribution of the National Parks to the provincial economy is evidently significant. However, we cannot overlook the importance of these sites to resident Nova Scotians. According to the information presented in Table about 319,577 visits to the three sites were made by Nova Scotians in 1981. Kejimkujik, in particular, is very important in providing Nova Scotians with recreational opportunities, having nearly 60% of its attendance from within the province. Although it is difficult to measure the dollar value of a recreational experience or of preserving a unique natural or cultural resource, it is irrefutable that a value does exist. If we consider that both Kejimkujik and Cape Breton Highlands National Parks experienced capacity weekends throughout the summer of 1981 at many campgrounds, the importance to local users is self-evident.

1.5.7 Summary

Employment, income, and recreational benefits attributed to the three parks have been estimated. Employment opportunitites result from the Parks hiring staff to construct, operate and maintain park facilities. Similarly, jobs are created as a result of purchases of goods and services. For 1981-82, a total of 1,147 jobs were estimated to have been directly and indirectly generated due to the existence of the three parks.

Through the use of income multipliers derived by Parks Canada's Socio-Economic Division research applied to Cape Breton Highlands (1.306) and Kejimkujik (1.108) National Parks, the total income effect was found to be about 22 million dollars for 1981-82. These may be somewhat conservative in view that the province of Nova Scotia utilizes a multiple of 1.6 for estimating tourist benefits. When including the expenditures of visitors to the three sites, the economic benefits become significant. It was estimated that over 80 million dollars will be spent by visitors to the three parks over the next five years.

Parks Canada's expenditures have amounted to 113 million dollars over the past ten years for the construction and maintenance of its facilities at the three parks considered. An additional 69.8 million dollars is projected to be spent by Parks Canada during the next five years as part of its ongoing program to protect and present these outstanding resource areas.

Most socio-economic benefits generated by the Fortress of Louisbourg in this section are not generated directly or indirectly on account of the natural resources managed in the park. Employment, expenditures and visitation for the most part is generated on account of Parks Canada's mandate towards the historic resources. Potential does exist, however, for increased use of the natural resource base by park visitors.

1.6. SUMMARY

Parks Canada is entrusted with the responsibility to protect for all time those places which are significant examples of Canada's natural and cultural heritage and also to encourage public understanding, appreciation and enjoyment of this heritage in ways which leave it unimpaired for future generations. The National Parks Act and Regulations passed in 1930 and the Historic Sites and Monuments Act passed in 1953 provide the mandate for carrying out this responsibility.

The present national park system, begun with the founding of Banff in 1885, presently embraces 29 national parks located across the country in every territory and province. Each park is representative of a natural region and is planned so it can protect and present the themes which it represents. Standards for natural resource management have been established for use throughout the national parks system and a natural resource management process manual is used to ensure uniform application of these standards.

On an international level, Canada's national parks are an important component of a world-wide endeavour to protect outstanding natural areas. Considered widely as ecological benchmarks for research into natural processes and into the relative effects of man on adjacent lands, national parks can also serve as "genetic pools" for man in the future.

The seven national parks located in the Atlantic Provinces look to a regional office in Halifax for policy, planning, administrative coordination, technical expertise, and operational direction. Two national parks, Cape Breton Highlands and Kejimkujik, are located in Nova Scotia. These two national parks together with a third Parks Canada property, Fortress of Louisbourg National Historic Park, have a land base equaling 2.5 per cent of the province's total area.

Natural resource management within the parks is the responsibility of the Warden Service aided by the Resource Management Advisor in the field. Resource management actions are based on data collected in basic resource inventories and studies, plus a resource monitoring program. A Resource Description and Analysis provides an extensively used reference document for all park managers. The Park Conservation Plan is a management aid which, based on resource management objectives, resource data, and park zoning, identifies topics of concern requiring attention and application of park manpower and financial resources. This Conservation Plan is updated annually.

Forests are the predominant landscape feature of both national parks in Nova Scotia. Parks Canada policy in the Atlantic Region ensures full protection of these forests against devastation through fire by allocating appropriate manpower and financial resources. The fire control record speaks for itself. In cooperative surveys with the Canadian Forestry Service, insect and disease conditions are monitored on an annual basis. Parks Canada policy allows manipulation of these naturally occurring infestations if a threat to neighbouring lands is evident.

Parks Canada properties in Nova Scotia offer both residents and visitors opportunities to enjoy outdoor recreational activities such as camping, canoeing, and hiking. An extensive interpretive program provides an educational experience for those interested in obtaining an understanding of the resource values protected in both national and historic parks.

The socio-economic impact of Parks Canada operations in Nova Scoita is substantial. During the fiscal year 1981-82, a total in excess of 900 jobs was estimated to have been directly and indirectly generated by the two national parks alone. Parks Canada expenditures have amounted to 54 million dollars over the past ten years for construction and maintenance of its facilities at these two national parks. An additional 40 million dollars is projected to be spent during the next five years as part of an ongoing program to protect and present these outstanding resource areas. Finally, it has been estimated that over 57 million dollars will be spent by visitors to these parks over the next five years.

In conclusion, Parks Canada, as a major land manager in Nova Scotia, strives to achieve the twin objective of making a meaningful contribution to the economic and social welfare of Nova Scotians, and, of carrying out its mandate to protect natural areas of significance to all Canadians so as to leave them unimpaired for the benefit and enjoyment of future generations.

1.7 RECOMMENDATIONS

Heritage Protection

Parks Canada's primary responsibility is the protection of our national heritage resources, national parks being the representative natural areas of Canadian significance.

In Nova Scotia, Cape Breton Highlands National Park represents the Maritime Acadian Highlands known as natural region 31, while Kejimkujik National Park is representative of the Atlantic Coast Uplands, natural region number 33, except that it lacks a coastal component.

Parks Canada has been given the mandate to fully represent by its system of national parks the heritage landscape values of Nova Scotia. But Heritage protection must extend beyond the efforts of the national government. To ensure valuable resources whose heritage values do not meet national criteria are protected all levels of government as well as industry and the public must be involved.

In the past, Parks Canada has provided advice and assistance to others on many projects involving heritage protection. This liaison has been both formal and informal, and Parks Canada has been involved with such projects as restoration of Halifax's Historic Properties, development of the Lunenburg Maritime Museum and the provision of information on trail standards for provincial parks and the proposed redevelopment of the sourth shore CNR grade. Parks Canada will continue to assist in the provision of assistance in protecting the nations's heritage within the constraints of available ressources.

Parks Canada commends the provincial government, local governments and the private sector for their efforts to protect and interpret heritage properties. The Special Places Protection Act of 1981 is an example of vital enabling legislation. The Nova Scotia Museum's efforts to identify rare and endangered species and their habitat and the "Theme Region of Nova Scotia" project will both assist the province in identifying those heritage lands for which special management objectives are required. The Natural Area of Canadian Significance preliminary study, prepared by Parks Canada in 1976, identified six special heritage areas in Nova Scotia outside of existing National Parks which should also be considered by provincial and local planners. The ecological reserves proposed by the International Biological Program and subsequent studies must also be carefully considered.

Heritage protection activities as practised by Parks Canada and other agencies are only one allocation of land and resources to be managed under the broad term "conservation". Land and resources dedicated as ecological reserves, recreation areas, shelter belts along streams, endangered species habitat and short rotation forestry can all be managed to meet the broad objectives of conservation. It is critical that land and resource allocations are carefully planned to meet the multi-facetted land use requirement of the people of Nova Scotia for this and future generations.

It is recommended that the Province of Nova Scotia extend its program of systematic land use planning so as to ensure the necessary land resources are available to all sectors of the community. The province while initiating and coordinating these efforts should involve all levels of government, industry and the public.

It is further recommended that in those lands with special resource or heritage values such as proposed ecological reserves, rare or endangered species habitat or in land with national or provincial heritage significance these resource values take precedence for management actions and only those activities that are compatible with the specialized objectives for these lands should be permitted. To catch up with the existing backlog of proposed areas, it is recommended that the province set goals to legislate protection for the proposed special areas under the Special Areas Act.

Finally, it is recommended that all sectors of the Nova Scotian and Canadian society become involved in protecting Nova Scotia's heritage and new, innovative and cooperative approaches be developed to achieve these ends.

Resource Management

National park environments are not isolated, but exist as an integral component of the biosphere. Those activities that occur outside a national park may disrupt natural processes and cause the deterioration of park resources. Likewise, national park activities or management practices can impact on resources outside the park. As examples of such interaction, mammal species protected inside a national park could cause considerable harm to tree plantations outside its boundaries, pesticides and other biocides can alter natural ecosystems by disrupting their natural processes, and exotic or cultivated plant and animal species can be introduced into a park's flora and fauna upsetting the natural life cycles.

It is accepted that it is impossible to eliminate all harmful effects to the natural ecosystem of a national park. For instance, Parks Canada itself utilizes chemical pesticides; but, it restricts their application to specialized circumstances (where there are no known alternatives) such as for the maintenance of golf course turf and where such application can be strictly controlled and monitored.

It is Parks Canada's policy to ensure national park management is integrated in a positive manner with regions surrounding national parks.

It is recommended that the province and private land holders surrounding national parks consult with Parks Canada to explore concerns being generated by various land use and management activities to offset or avoid negative impacts on both sides of the boundaries. When local management or advisory boards exist, Parks Canada should participate as a member in the review of these concerns. In the absence of formalized review processes, it is recommended that the Park Superintendent be kept informed of land use proposals surrounding the park by the provincial department of Lands and Forests or other regulatory agencies.

It is also recommended that the provincial government and private land owners establish necessary contacts with Parks Canada so that when their lands could be affected by planned-for park management actions or development, they could be contacted for discussions. The logical contact in Parks Canada is, the Park Superintendent.

It is further recommended that the province ensure that chemicals including pesticides utilized for various resource management practices or waste from other activities are not introduced into national parks. The province may consider the establishment of buffers around park boundaries and waters that flow into parks or special regulations as options to meet this objective.

The potential of National Parks to protect genetic stocks is just now being fully appreciated by many.

Parks Canada has to date not formalized procedures for the collection and distribution of genetic materials from various floral species as it has with wildlife. Parks Canada would prefer to utilize established institutions such as the National Tree Seed Centre of the Canadian Forestry Service and the Canadian Wildlife Service to coordinate the collection and distribution of the genetic material protected in national parks. Beyond this Parks Canada will cooperate whenever possible with siviculturalists, wildlife managers and others who have a use for the genetic materials protected inside National Park boundaries.

It is further recommended that the forest industry and others such as wildlife managers interested in the enhancement and future use of the

genetic resources protected within National Parks provide Parks Canada with suggestions as to their future management. These suggestions should consider appropriate central agencies best suited to coordinate the distribution and cataloguing of these genetic materials in Canada so as to ensure their most effective use in selective breeding experiments.

Parks Canada and Nova Scotia Lands and Forests informally cooperate in forest fire control. Lands and Forests assists in training Parks Canada fire control personnel and both agencies provide operational assistance if resources are available when requested.

It is recommended that informal forest fire control cooperation between Parks Canada and the province be continued.

National Park Wardens cooperate with enforcement agencies of many provinces and territories in the application of their provincial fish and game regulations and federal fisheries regulations. Generally, this occurs along park boundaries in association with regular park fish management, road or backcountry patrols.

It is recommended that Parks Canada and the province explore the potential for this cooperation for their mutual benefit around National Parks in Nova Scotia.

Research

National Parks provide opportunities to carry out research on the processes of natural systems. The long-term protection of national parks makes them exceptional locations for baseline studies and controls for comparison to manipulative research occurring outside park boundaries.

Research or monitoring inside parks, however, is regulated so that the long-term protection of park resources will be ensured.

Parks Canada is pleased to have this opportunity to make the provincial government, private industry and research institutions aware of the research opportunities offered by national parks.

Parks Canada would also like to ensure that others are aware of the research and inventories that have been conducted on park lands and the results stored in various libraries. Further dissemination of this information is likely to assist others doing related work. Modern on-line computerized bibliographies such as that maintained by Parks Canada's Documentation Centre will enhance referencing this literature.

It is recommended that researchers consider the use of Parks Canada's resources when designing and conducting nonmanipulative research.

It is further recommended that the province establish a centralized resource centre with modern on line computerized capability to be a central repository of natural resource related research in the province.

Forest Land Recreation

National Parks offer a variety of outdoor recreation opportunities, which provide a means for park visitors to enjoy and understand the park's natural environment and which are consistent with the protection of park resources. National Parks cannot fulfill the demands for all outdoor recreational pursuits. Many activities would seriously disrupt those resources which the parks were specifically designed to protect. Overuse of established National Park activities would be equally destructive. Two National Parks in Nova Scotia cannot provide for all the forest lands recreational needs related to forest lands demanded by a resident population or visitors spatially distributed throughout the province.

Parks Canada would like to commend the province and private industry, including the forest industry for their activities to date in developing campgrounds, picnic sites, trails, ski hills and other outdoor recreation facilities. The provincial canoe trip guides are excellent. Outdoor recreational users are legitimate users of woodlands and it is important that their needs are adequately provided for. Their needs are diverse. The multi-day canoe tripper is not the cross country skier or evening walker out for a short workout. The resources required and their placements are quite different. Only by developing an overall outdoor recreation strategy can the overall needs of visitors and residents alike be recognized and planned for.

When outdoor recreational users needs are not met, the users often attach blame to what they see as competing users whose activities appear to exclude or discourage the recreationalists from utilizing what they perceive to be a public resource. Many strong conservation lobbies have formed around core groups of outdoor recreationalists.

Often the most effective and economical means of developing and maintaining low-key facilities and services such as trails, shelters and brochures is by involving these same individuals, the users. The existing Nova Scotia booklets on bicycle tours and hiking trails are good examples of this process at work.

It is recommended that the province should solicit the cooperation of the Federal and local governments, private industry, private land owners and outdoor recreationalists and their organizations to develop and implement a strategy to meet the present and projected needs for forest lands recreation in Nova Scotia.

Future Liaison with the Forest Industries

Parks Canada wishes to thank the Province of Nova Scotia and this Commission for the opportunity of submitting the information contained in this portion of the brief. It has been submitted in the hope that it will bring about a better understanding of Parks Canada's mandate and operation in Nova Scotia by others involved with Nova Scotia's forests. It is also hoped that this brief may provide other forest managers with insight into how National Parks can be of benefit to the forest industry in the future.

We find ourselves in a dynamic world. Technology and information available to us are expanding at a rapid pace. In response human needs are constantly changing. Government policy and regulations attempt to respond. This commission has provided one opportunity in time for various segments of our society involved in Nova Scotia's forest to talk to one another. To make most effective use of our forest lands, this liaison must continue.

It is recommended that an informal committee representing all segments of Nova Scotian society involved in Nova Scotia's woodlands be established to facilitate this liaison in the future. This committee would review government policy and like this commission review with all concerned recommendations involving Nova Scotia's woodlands in the future.

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APPENDICES

Chapter 1 PARKS CANADA'S ATLANTIC REGION ORGANIZATION

Parks Canada Program Headquarters located in Hull, under the Assistant Deputy Minister, is responsible for broad policy formulation, program coordination, systems planning, long range research and liaison and consultation.

In the four Atlantic provinces, the Atlantic Regional Office is responsible for the protection, operation, development and interpretation of 7 National Parks, 23 National Historic Parks and the historic St. Peters Canal. It is also responsible for the maintenance of over 300 National Historic Sites, which commemorate people, places and events of national historic significance. Figure 1 shows the location of the Region's seven national parks.

Each park is the direct responsibility of a Superintendent. His or her staff is backed by a team of specialists working out of the Regional Office in Halifax. Guided by the Director, Atlantic Region, who reports to the Assistant Deputy Minister, this support group is responsible for the day-to-day direction of the parks and carrying out specific applied research and operational planning in cooperation with Program Headquarters.

1.1 Atlantic Regional Office Organization

A group of senior managers reports to the Director, Atlantic Region, as do the Superintendents of National Parks and National Historic Parks and Sites.

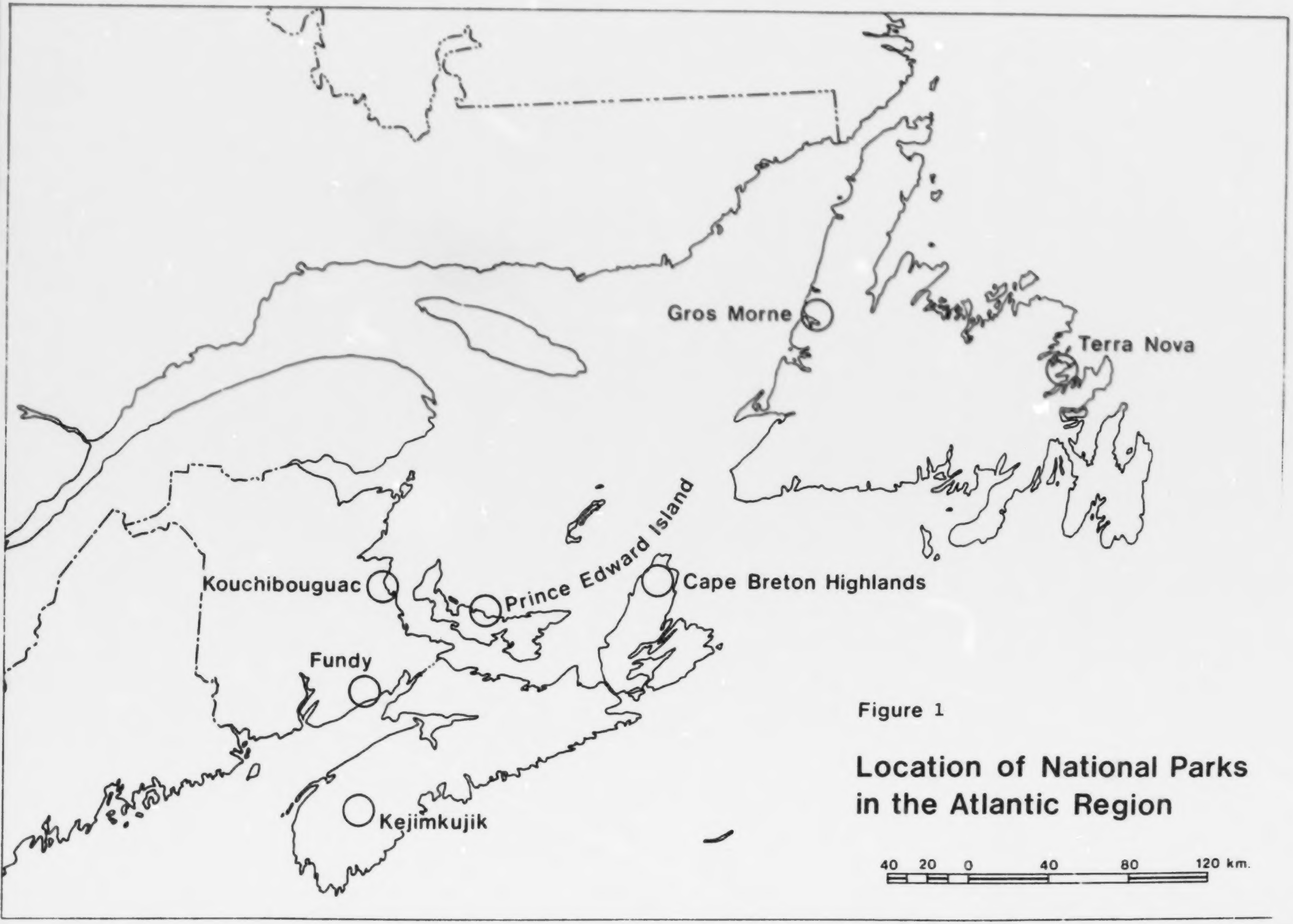

Gros Morne
Terra Nova
Prince Edward Island
Cape Breton Highlands
Kouchibouguac
Fundy
Kejimkujik
40 20 0 40 80 120 km.

Figure 1

Location of National Parks in the Atlantic Region

The Assistant Director (Operations) provides functional guidance to, and is responsible for operations of, National Parks and National Historic Parks and Sites in the region.

The Assistant Director (Policy Planning and Research) directs and coordinates conceptual plans and master plans for regional National Parks and National Historic Parks and Sites; directs research on visitor facilities, cultural and historical features.

Support services also reporting to the Director include the Regional Engineering and Architectural Division, the Administration Division and Information Services. The total complement of the Regional Office is approximately 200 of whom 150 are full-time employees.

The Assistant Director (Operations') responsibilities cover four main areas:

1. Natural Resource Conservation
2. Interpretation
3. Visitor Services and Administration
4. Historic Resource Conservation

These sections are responsible in turn for advice to the Parks and Historic Parks and Sites for their own specific areas of concern.

Natural Resource Conservation Section is directly concerned with the management and protection of the natural resources, which includes not only the forests, but also the water in the parks and sites, and the fauna and flora associated with the major elements of the natural resource base. Its role is defined as "to assist and, where appropriate, provide functional advice and guidance to park, Regional and program staffs engaged in, or contributing to, the management of natural resources, the security and safety of people, the security of facilities and historic and cultural resources and the enforcement of law and order and to monitor these for effectiveness and for consistency with prescribed policies, standards, procedures and practices". (Parks Canada 1980)

1.2 National Parks Organization

The individual National Parks are managed using a corresponding organization to that in Region.

The Park Superintendent, who reports to the Regional Director, is responsible for the day-to-day operation of the park. The five operational divisions, each headed by a manager, are as follows: Administration, Warden Service, Interpretive Service, Visitor Services, and General Works. A sixth park officer, the Natural Resource Management Advisor, also reports to the Park Superintendent.

Administration and General Works (Maintenance) staff provide support to the park's operational staff ensuring financial, personnel and facility related matters permit efficient and effective park operations.

Three park sections make up park operations. Visitor Services staff are responsible for providing various visitor services, such as distributing park information and the operation of visitor facilities such as campgrounds and hiking trails.

Interpretation staff operate plan design and operate non-personal interpretive media, such as exhibits and audio-visual presentations. Personal contact with a park interpreter during a campfire program or a guided canoe trip is often the highlight of a park visitor's experience.

The management and protection of the natural resources fall under the responsibility of the Natural Resource Conservation Section, whose main complement is the Park Warden Service assisted by the Natural Resource Managment Advisor.

The authority for law enforcement in these areas lies in the National Parks Act. Regulations to cover all law enforcement activities are contained in the National Park regulations. Park wardens are designated peace officers and have as one of their primary responsibilities law enforcement.

The Warden Service is comprised of skilled technicians in various aspects of natural resource management. The Resource Management Advisor provides professional support to assist the wardens in their resource related duties. Generally, the park wardens conduct most environmental screenings, prepare park conservation plans, resource management plans and co-ordinate the program of environmental monitoring. The Resource Management Advisor usually has primary responsibilities of maintenance of the park data base, co-ordination of the Resource Description and Analysis and inputing as a team member to the Park Management Plan. At the Park level, direct cooperative actions are carried out with the appropriate Federal and Provincial agencies.

Chapter 2 NATIONAL PARKS IN NOVA SCOTIA

Two national parks are located in Nova Scotia ... Kejimkujik in the western end of the province, and, Cape Breton Highlands at the eastern extremity (Figure No. 2). Together, they occupy 2.4 per cent of the total area of the province. Kejimkujik National Park represents the Atlantic Uplands portion of the natural region described as the Atlantic Coast Uplands. This region is characterized by the interconnected lakes, streams, and low, rolling topography of inland Nova Scotia. Cape Breton region and is exemplified by the rugged coasts, plateaus, and deeply incised valleys of Cape Breton Island. These two parks adequately represent Nova Scotia's two natural regions with one major exception. The important coastal component of the Atlantic Coast Uplands is not found in either park.

2.1 Cape Breton Highlands National Park

2.1.1 Historical Background

The first proposal that a national park be established on Cape Breton Island was made in 1928. Two years later a strong recommendation was made to have Cape Blomidon, a prominent feature overlooking Minas Basin at the head of the Bay of Fundy, be considered as a future national park. In 1934, Premier Angus Macdonald requested the Minister of the Interior in Ottawa to consider and inspect three sites in Nova Scotia: one at Cape Blomidon, one in Yarmouth County and a third in northern Cape Breton Island. The following year, Premier Macdonald confirmed that the Government of Nova Scotia was prepared to grant to Canada for a park clear title to lands which would be mutually satisfactory to both governments. Consequently, the "Cape Breton Highlands National Park" was established by proclamation under authority of the Nova Scotia and Prince Edward Island National Parks Act in 1936, and became the first National Park in the Atlantic Provinces.

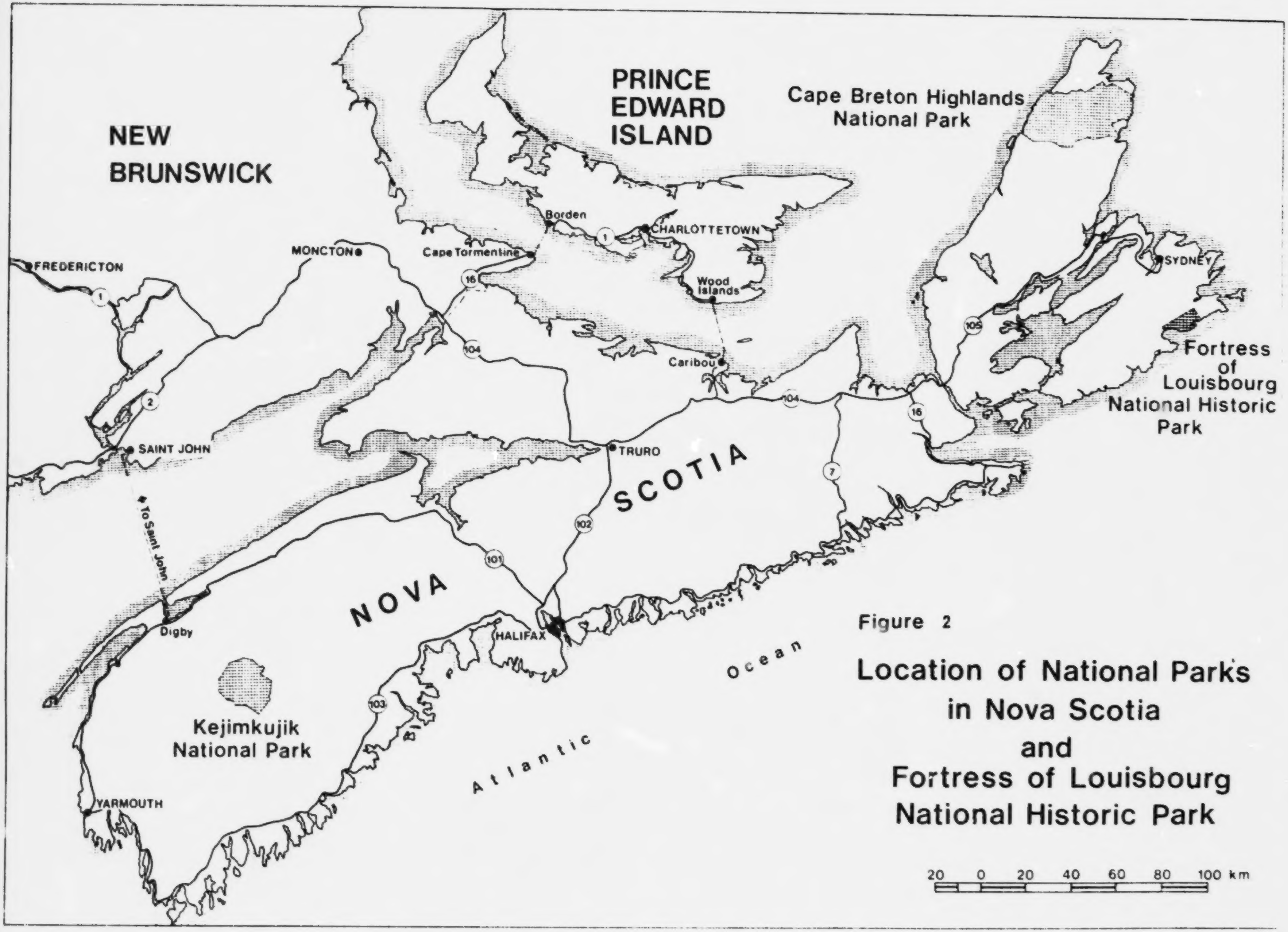

PRINCE EDWARD ISLAND
Cape Breton Highlands National Park
NEW BRUNSWICK
Borden
CHARLOTTETOWN
1
MONCTON
Cape Tormentine
FREDERICTON
16
1
Wood Islands
SYDNEY
105
104
Caribou
Fortress of Louisbourg National Historic Park
2
104
16
SAINT JOHN
TRURO
SCOTIA
7
To Saint John
102
101
NOVA
Digby
HALIFAX
Ocean
103
Kejimkujik National Park
Atlantic
YARMOUTH
20 0 20 40 60 80 100 km

Figure 2

Location of National Parks in Nova Scotia and Fortress of Louisbourg National Historic Park

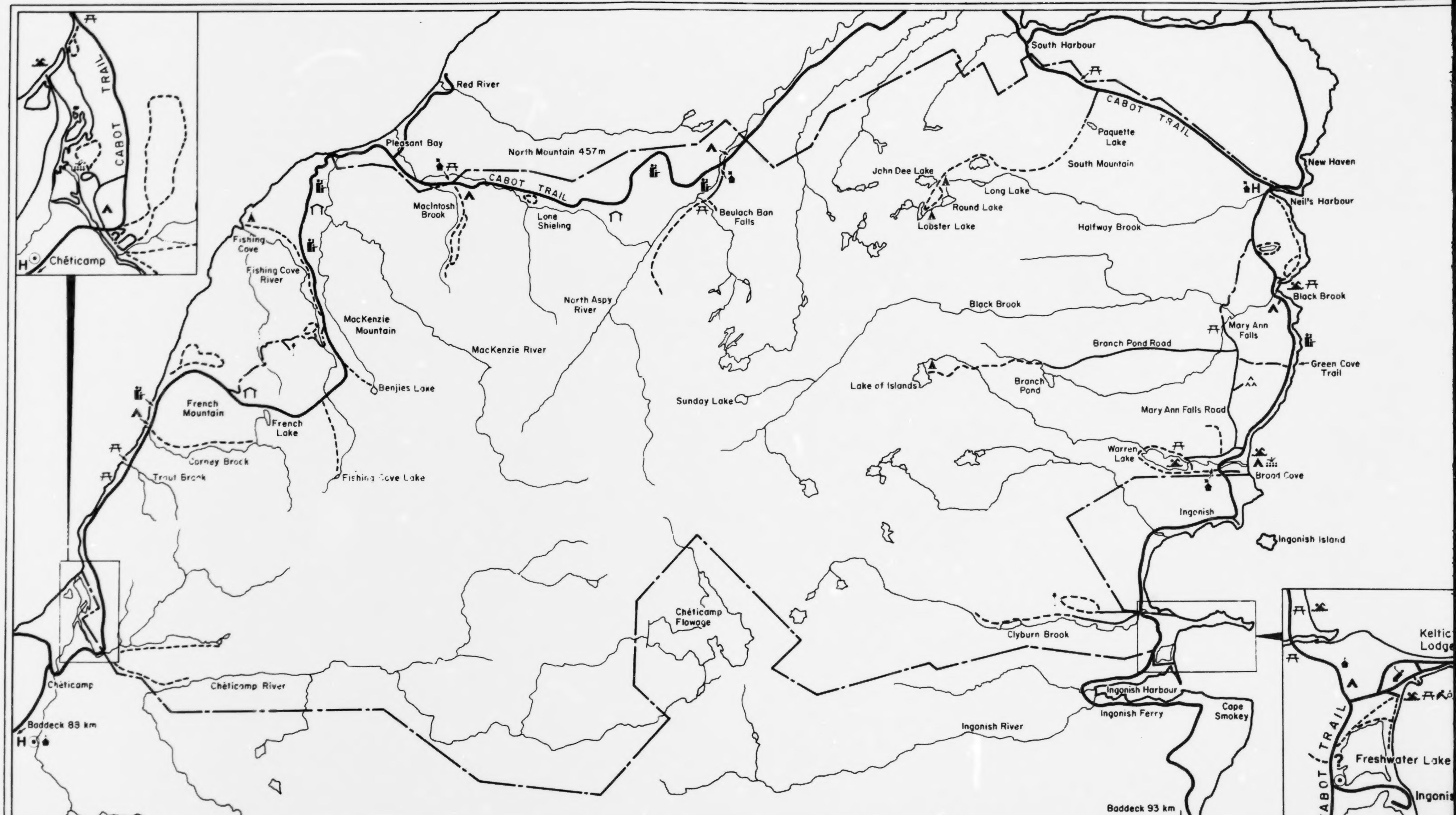
Shortly following the Park's creation, there were difficulties in settling claims of free-hold properties in the Pleasant Bay area which resulted in revisions to the park boundary. Further adjustments in the boundary were made some years later. In 1956, an area in the southwestern section of the Park south of Cheticamp River was withdrawn at the the request of the province to facilitate mineral development. Again, in 1958, land in the vicinity of Cheticamp Lake was withdrawn from the Park to facilitate hydroelectric development sponsored by the Province of Nova Scotia.

2.1.2 Physical Background and Park Facilities

Bounded on the west by the Gulf of St. Lawrence and on the east by the Atlantic Ocean, Cape Breton Highlands National Park's main feature is an extensive plateau which covers 90 per cent of its area. Rising 360 meters above sea level, the plateau is reached by the Cabot Trail. The spectacular scenery along this road is one of the Park's most prized features. Strategically placed park facilities complement this scenic setting. These are shown in Figure 1.3.

2.1.2.1 Geographical Location and Access

Located in the northern portion of Cape Breton Island, the Park may be reached by travelling along the Cabot Trail to Ingonish on the Island's eastern shore, or by travelling along the trail to Cheticamp on the Island's western shore. The Cabot Trail provides access through the eastern, northern, and western areas of the Park. There is no road access to central and southern areas. The second largest park in the Atlantic Provinces, Cape Breton Highlands encompasses some 950 square kilometers. The major portion of this area comprises some of the last remaining wilderness in Nova Scotia.


CABOT TRAIL
H
Chéticamp
Red River
Pleasant Bay
North Mountain 457 m
CABOT TRAIL
MacIntosh Brook
Lone Shieling
Beulach Ban Falls
South Harbour
CABOT TRAIL
Paquette Lake
South Mountain
John Dee Lake
Long Lake
Round Lake
Lobster Lake
Halfway Brook
New Haven
H
Neil's Harbour
Fishing Cove
Fishing Cove River
MacKenzie Mountain
North Aspy River
MacKenzie River
Black Brook
Black Brook
Mary Ann Falls
Branch Pond Road
Green Cove Trail
Benjies Lake
Sunday Lake
Lake of Islands
Branch Pond
French Mountain
French Lake
Mary Ann Falls Road
Corney Brook
Trout Brook
Fishing Cove Lake
Warren Lake
Broad Cove
Ingonish
Ingonish Island
Chéticamp Flowage
Clyburn Brook
Keltic Lodge
Chéticamp
Chéticamp River
Ingonish Harbour
Ingonish Ferry
Cape Smokey
Ingonish River
Freshwater Lake
Baddeck 83 km
H
Baddeck 93 km
CABOT TRAIL
Ingonis

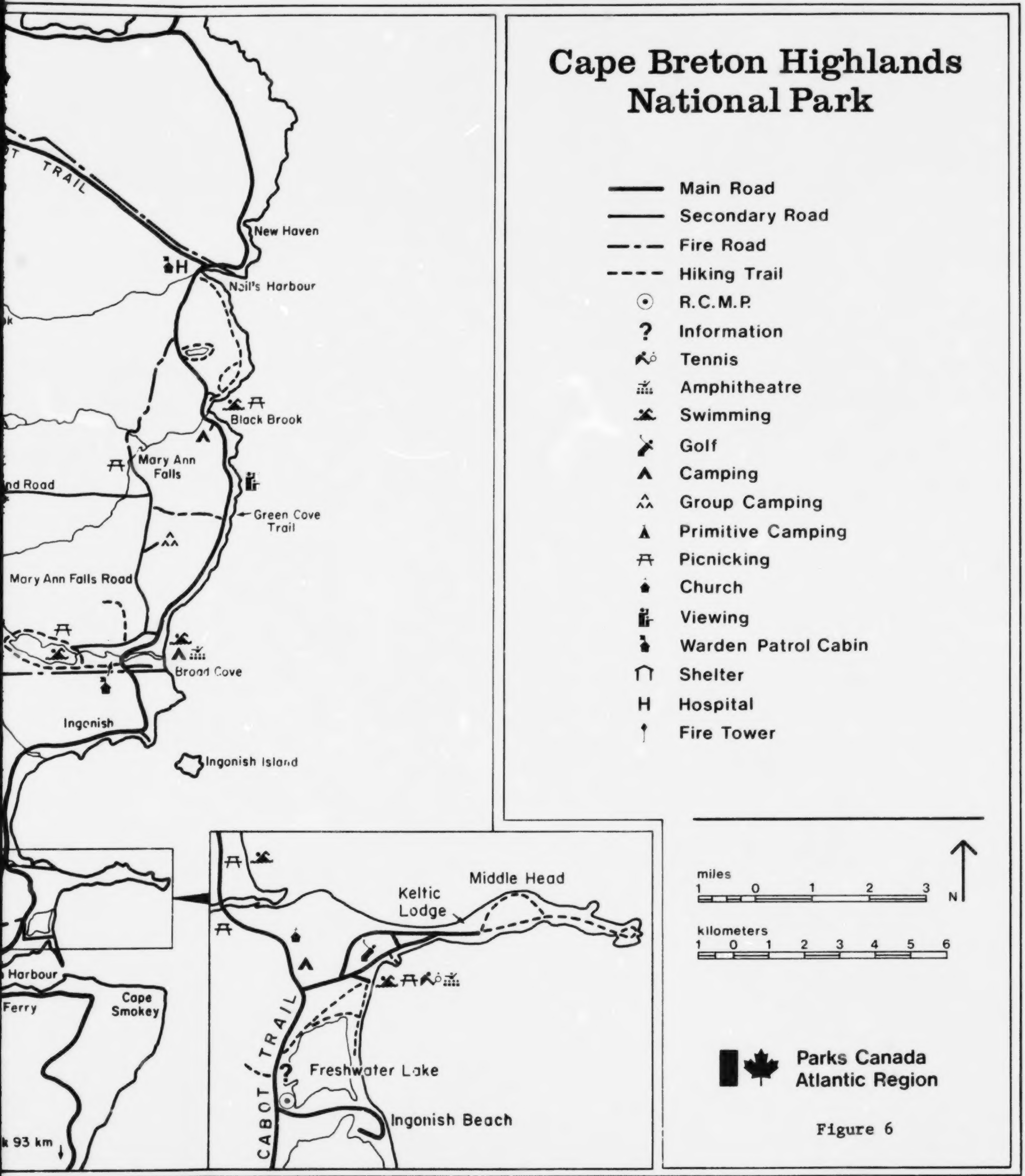

Cape Breton Highlands National Park
Main Road
Secondary Road
Fire Road
Hiking Trail
R.C.M.P.
Information
Tennis
Amphitheatre
Swimming
Golf
Camping
Group Camping
Primitive Camping
Picnicking
Church
Viewing
Warden Patrol Cabin
Shelter
Hospital
Fire Tower
miles
1 0 1 2 3
kilometers
1 0 1 2 3 4 5 6
N
Parks Canada
Atlantic Region
CABOT TRAIL
New Haven
H
Neil's Harbour
Black Brook
Mary Ann Falls
nd Road
Green Cove Trail
Mary Ann Falls Road
Broad Cove
Ingonish
Ingonish Island
Harbour
Ferry
Cape Smokey
k 93 km
Middle Head
Keltic Lodge
Freshwater Lake
Ingonish Beach
CABOT TRAIL

Figure 6

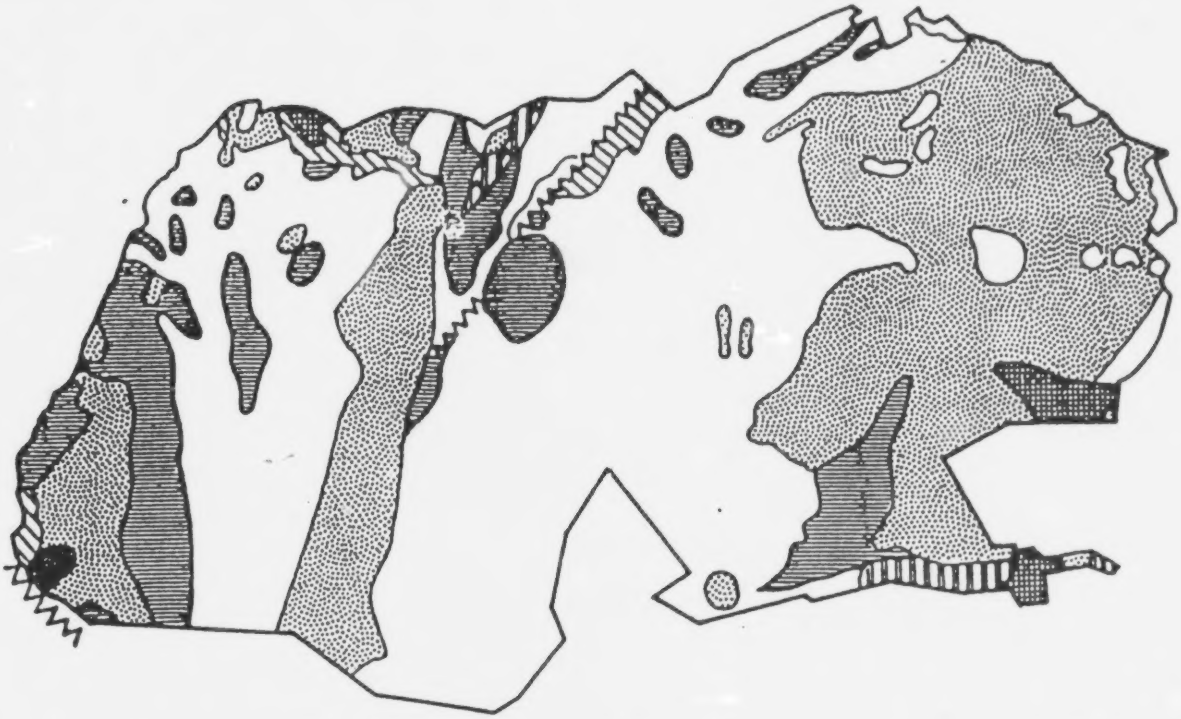
access to central and southern areas. The second largest park in the Atlantic Provinces, Cape Breton Highlands encompasses some 950 square kilometers. The major portion of this area comprises some of the last remaining wilderness in Nova Scotia.

2.1.2.2 Topography

Bounded on the east by the Atlantic Ocean and on the west by the Gulf of St. Lawrence, the Cape Breton Highlands National Park includes a vast tableland with deep valleys and bold headlands facing the open sea. Perched boulders and other glacial debris dot the terrain, which also contains numerous bog ponds, lakes and streams.

Three primary bedrock structures characterize much of the park. (Figure 4) The core of the highlands consists of very old Precambrian George River rocks. Small pockets of these rock types extend up the Park's eastern coast while larger areas of it also occur along the Park's western coast. The second significant rock element is the granitic type which outcrops in a large batholith in the eastern portion of the park, west of Ingonish and Neil's Harbour, and forms fingerlike projections in several areas in the central and southwestern regions of the park. Finally, exposures of carboniferous sandstones and conglomerates occur in a number of the larger canyons such as Grand Anse, Aspy, Cheticamp and Warren Brook.

The Park's east, north and west edges are for the most part very well drained with streams being characteristically short and subject to drying up during periods of low precipitation. Many of these same intermittent streams provide approximately one-third of the park's area with rapid to very rapid drainage during wet seasons of the year.



Palaeozoic

CARBONIFEROUS

MISSISSIPPIAN

▦ **Windsor Group**
Limestone, gypsum, anhydrite, shale, sandstone, conglomerate, salt; includes MACUMBER, PEMBROKE AND TENNYCAPE FORMATIONS; McARAS BROOK AND ARDNESS FORMATIONS: ST. ANN and GRANTMIRE FORMATIONS.

▨ **Horton Group**
Sandstone, shale, conglomerate, arkrose; includes HORTON BLUFF AND CHEVERIE FORMATIONS: RIVER JOHN GROUP; CRAIGNISH-STRATHLORNE AND AINSLIE FORMATIONS

DEVONIAN

MIDDLE DEVONIAN OR LATER

■ Conglomerate, sandstone, siltstone; volcanic breccia tuff, lava (post-granite), pre-Horton

LOWER AND/OR middle DEVONIAN
(wholly or mainly)

░ Granitic and allied rocks

▥ Dioritic and gabbroic rocks / A, anorthosite

Archaean and/or Proterozoic

CAMBRIAN (mainly)

□ Mainly George River rocks (1) intruded by granitic rocks (4); composite gneiss; hybrid rocks; mixed rocks (Precambrian and Palaeozoic (?))

▤ **George River Group**
Quartzite, schist, gneiss, crystalline limestone.

FIGURE 4 : MAP OF CAPE BRETON HIGHLANDS NATIONAL PARK SHOWING THE MAIN GEOLOGICAL FEATURES

The land forms and surficial material types found in the Park are shown in Table 1.

TABLE 1: PERCENTAGE OCCURRENCE OF LANDFORMS, SURFICIAL MATERIAL TYPE AND SURFICIAL MATERIAL DRAINAGE CLASS IN CAPE BRETON HIGHLAND NATIONAL PARK

Landform Type	Percentage Occurrence
Hill	13
Depression	1
Side Slopes	19
Organic Flats	4
Canyons	6
Ridge-Depressions	12
Hill Complex	18
Flat	27
	100

Surficial Material Type	Percentage Occurrence
Deep Glacial Till	8
Compacted Glacial Till	35
Exposed Bedrock with Till Pockets	17
Colluvium	23
Glacio-gluvial & fluvial sediment	7
Organic matter	10
	100

The generally rugged topography of the Park is apparent when one notes that less than one-third of its area is described as flat. The most common surficial material type, compacted glacial till, covers one-third of the park's area, while Colluvium and exposed bedrock with till pockets together account for forty per cent.

2.1.2.3 Climate

Climatic conditions in Cape Breton Highlands National Park are undoubtedly influenced by winds travelling across open expanses of water of the Gulf of St. Lawrence. The presence of this body of water may explain to some degree the large amounts of snowfall recorded for the region. Climatic conditions on the Cape Breton Plateau seem to differ markedly from those which occur at lower elevations along the coastal portions of the Park. Although little useful information is readily available, it appears that the plateau area of the Park has more rain, stronger and more frequent winds, more snow which lasts longer, lower average daily temperatures, higher relative humidities and shorter growing seasons than do the lowland areas.

There are three weather stations in the park for which thirty-year summaries have been developed. These stations are located in Ingonish, Pleasant Bay and Cheticamp. No long-term climate information is available from a highland location.

The mean annual temperature for the coastal reaches of the park ranges between 5° and 8° Celcius. At the same time, the mean annual temperature for the highland regions is less than 5° Celcius. Winter on the lowlands of northern Cape Breton normally begins in early December and much earlier in the highlands and lasts for about four and one-half months.

Statistics indicate that, on the average, more than 1,600 millimeters of total precipitation fall on the southeastern area of the park. Between 1,400 and 1,600 millimeters of precipitation characterize most of the remainder of the plateau and northern areas, while 1,200 and 1,400 millimeters fall along the Park's western boundary. Mean total annual snowfall for the central and western highlands of the Park exceeds 400 centimeters. Similar snowfall values in other areas of the Maritime are found only in northern New Brunswick.

2.1.2.4 Vegetation

The vegetation of Cape Breton Highlands National Park is at once both simple and complex; simple in that a very large proportion of the land area exhibits vegetation types not typical of areas extensively influenced by human activity, and, complex because the natural limits of two, if not three, of the continent's major vegetation formation types coincide in northern Cape Breton Island. (Eastern Ecological Research Ltd., 1978) Excellent, undisturbed examples of the Acadian and the Boreal forests occur within the Park's limits as do numerous samples of the Boreal-Taiga transition scrubland. The transition of the Acadian to Boreal forest is particularly well illustrated on some of the steeper western slopes and river valleys. Taiga scrubland is restricted to the 400 meter high prominences which characterize the central highlands of the park. Approximately 21 per cent of the land surface is occupied by the Acadian forest, 65 per cent by Boreal forest vegetation types and 14 per cent by the scrubby Taiga forest and associated barrens. In all, 27 tree species groups and non-forested vegetation types were studied and mapped. Several of the non-forested types documented have in turn been subdivided into distinct plant associations and subassociations. This information is presented in Table 2 and the abundance of the Park's vegetation types is shown in Figure 5.

TABLE 2 TREE SPECIES GROUPS AND NONFORESTED VEGETATION TYPES FOR CAPE BRETON HIGHLANDS NATIONAL PARK

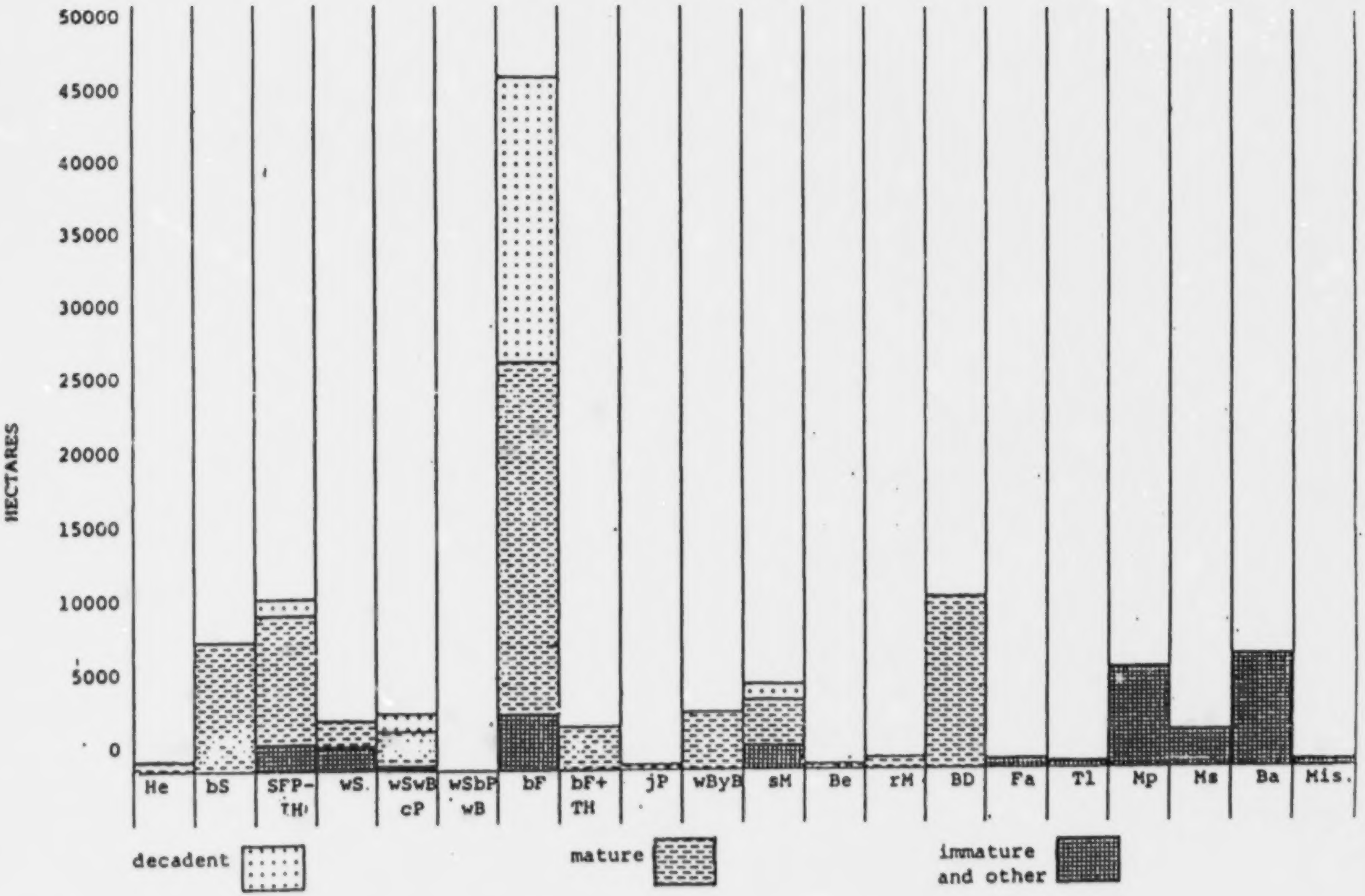
SPECIES GROUP, VEGETATION TYPE	LAND REGION	OCCURRENCE (HA.)	TYPICAL HABITAT
(Ha) 1. Hemlock	Acadian	271.7	Well drained lower slopes
(Be) 2. Beech	Acadian	181.0	Well drained lower slopes
(sM) 3. Sugar Maple	Acadian	4,829.7	Deep soils, lower to middle slopes
(wByB) 4. White Birch, yellow birch	Acadian	1,688.5	Mid-upper slopes
(bF-TH) 5. Balsam fir-tolerant hardwoods	Acadian	1,418.4	Shallow rocky slopes
(SFP-IH) 6. Spruce, fir, pine-intolerant hardwoods	Acadian	4,460.9	Burned, shallow soiled sites
(SFP-IH) 7. Balsam fir, black spruce	Acadian	2,626.0	Burned
(SFP-IH) 8. White birch, trembling aspen, red maple	Acadian	715.7	Burned
(rM) 9. Red Maple	Acadian	221.9	Burned organic, drainage ditches
(jP) 10. Jack pine	Acadian	153.6	Burned, very shallow soils
(wS) 11. White spruce	Acadian	1,070.0	Abandoned farm field
(Fa) 12. Fields	Acadian	163.6	Streams, valleys, crests and slopes
(Tl) 13. Talus	Acadian	135.2	Rock debris slope
(wSbPwB) 14. White spruce, balsam poplar, white birch	Acadian	51.2	Very shallow soils, floodplains
(bS) 15. Black spruce	Boreal, Taiga	7,613.2	Bog edges, wet depressions
(Mp) 16. Sphagnum mire	Boreal, Taiga	4,024.4	Wet depressions, bogs

TABLE 2 TREE SPECIES GROUPS AND NONFORESTED VEGETATION TYPES FOR CAPE BRETON HIGHLANDS NATIONAL PARK

SPECIES GROUP, VEGETATION TYPE	LAND REGION	OCCURRENCE (HA.)	TYPICAL HABITAT
(Ms) 17. Sedge mire	Acadian, Boreal, Taiga	1,098.0	River, lake edge
(bF) 18. Balsam fir	Boreal Taiga	44,097.3	Gently rolling hills
(bF) 19. Balsam fir, white birch	Boreal	3,135.6	Gently rolling hills
(bF) 20. White birch, balsam fir	Boreal	798.0	Regenerating forests
(wSwBcP) 21. White spruce, white birch, pin cherry	Boreal	2,374.8	Burned, exposed slopes
(BD) 22. Dwarf black spruce	Taiga	8,446.4	Windswept hilltops
(Ba) 23. Barrens	Taiga, Boreal	4,888.4	Windswept prominences, hilltops
(Mis.) 24. Miscellaneous	N/A	180.4	N/A

FIGURE: 5 CAPE BRETON HIGHLANDS NATIONAL PARK

ABUNDANCE OF VEGETATION TYPES



2.1.2.5 Fauna

The fauna of Cape Breton Highlands National Park is represented by native species of each major class of the animal kingdom. Most of the large mammals of eastern Canada, such as deer, fox, lynx and black bear are native to the Park. In all, thirty-two species, including the eastern cougar, are documented in the Park's mammal inventory (Prescott, 1980). Four additional species are hypothetical, one is an occasional visitor (the arctic fox) and two (the woodland caribou and timber wolf) are extinct.

The Park's avifauna is varied and includes shore birds, woodland species, birds of prey, seabirds, waterfowl and colonial nesters. A total of 181 species are known from the Park (Park Checklist) and another 23 species occur in the vicinity of Park boundaries.

The reptile and amphibian classes, while not particularly rich from a species diversity point of view, comprise a very numerous and easily observed group of animals. There are four species of salamanders and newts, seven species of frogs and toads, four snake species and two species of turtles. The ring necked snake may represent a range extension while the observation of turtles (wood and snapping turtles) is very interesting since turtles are not supposed to be present on Cape Breton Island.

The fish fauna is fairly restricted in species numbers and includes anadromous and freshwater forms. Of importance to the Park's sport fishery are Atlantic salmon, sea-trout and resident brook trout. Gaspereaux, smelt and eels also enter the Park's fresh water. Sticklebacks are found in a variety of aquatic habitats.

The Park's invertebrate fauna has not been studied in detail to date, apart fom work carried out in relation to forest defoliating insect species.

2.1.2.6 Park Facilities and Services

The Park has a full range of campgrounds with a total of 850 campsites. Some campgrounds offer heated service buildings with showers, individual three-way hookups, and fully landscaped sites. Others are more primitive, having pit privies, fire grills, and a source of water. One group campground is available to organized parties. Fully equipped picnic sites are strategically located throughout the Park. Some twenty-eight trails have been laid out for benefit of hikers. Golf, tennis, swimming and outdoor theatre facilities have been developed for use by park visitors. Information centres at the Cheticamp and Ingonish entrances to the Park are open from mid-May until mid-October. An extensive interpretive program provides both personal and non-personal programming year round.

2.1.3 Park Staff Organization

The Park Superintendent, who reports to the Regional Director, is responsible for the day-to-day operation of the Park. The five operational divisions, each headed by a manager, are as follows: Administration, Warden Service, Interpretive Service, Visitor Services, and General Works. A sixth park officer, the Natural Resource Management Advisor, also reports to the Park Superintendent. The Park Warden Service consists of a Chief Park Warden, seven full-time Park Wardens and six seasonal Park Wardens.

2.1.4 Natural Resource Conservation

Natural Resource Conservation at Cape Breton Highlands National Park is an ongoing program which follows procedures laid down in Parks Canada's Natural Resource Management Process Manual. The Park has completed a comprehensive basic resource inventory, while some resource studies have been completed and others are ongoing. Preparation of a Resource Description and Analysis is underway and a Park Conservation Plan will be completed in 1983. Several Natural Resource Management Plans are in place and an appropriate natural resource monitoring program has been established.

2.1.4.1 Basic Natural Resource Inventory

The basic natural resource inventory in Cape Breton Highlands National Park took the form of an Ecological Land Classification carried out in 1978. It provided comprehensive information on the major natural resource components in the park. It will serve as a benchmark statement of the status of the natural resources in the park so that future comparisons can be made.

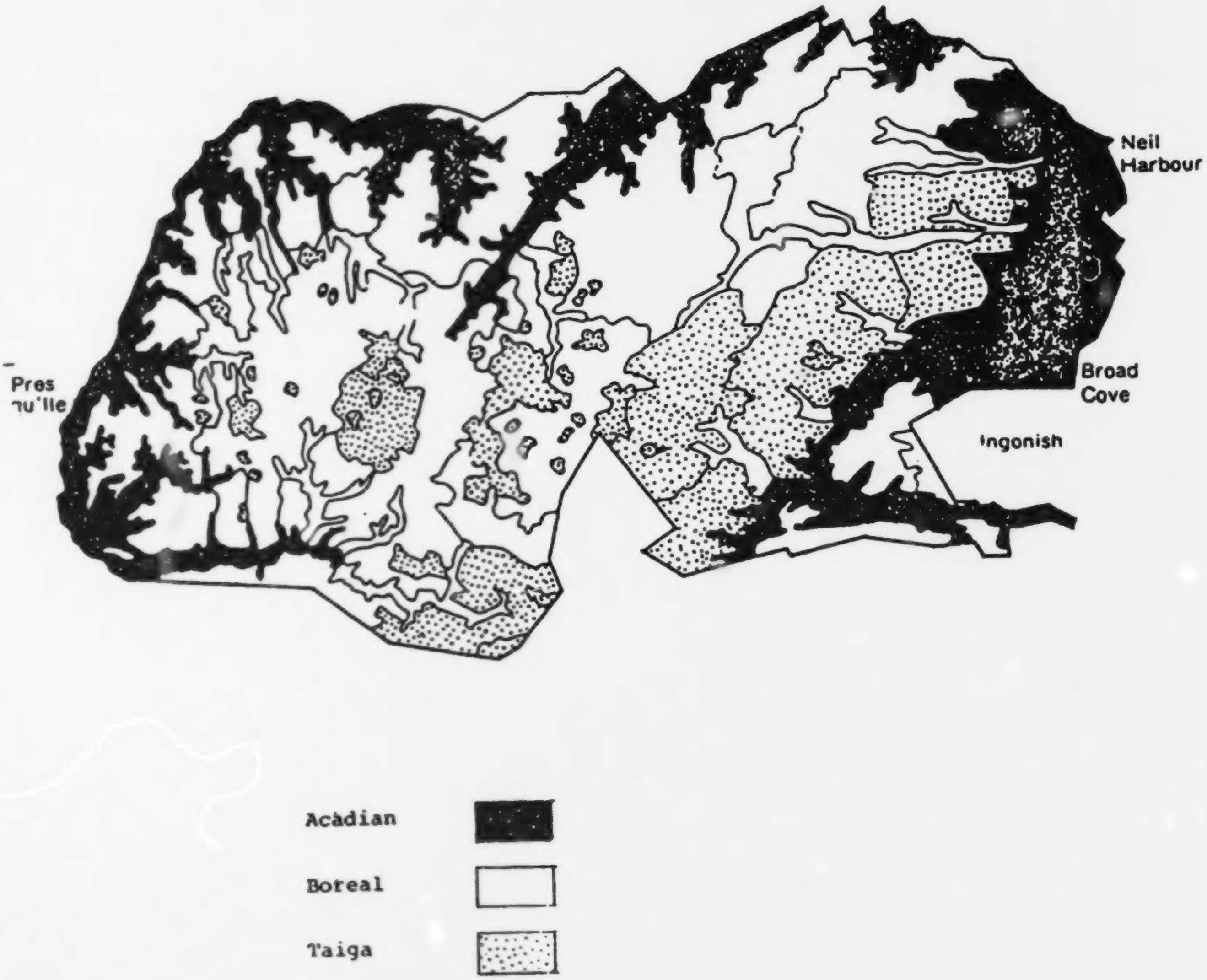
Work is now underway on the Park Management Plan. Completion is expected in 1985. Zoning, which was part of the Provisional Master Plan (1970), is currently utilized as a guide to park management, however it will not be formalized until the management plan is approved.

The Ecological Land Classification identified three land regions within the park. (Figure No. 6) A description of them and their components is as follows:

The Acadian Land Region is characterized by steep walled canyons rising to 330 meters on the park's western and eastern coasts and by a broad, flat plain sloping gently to the Atantic Ocean on its northeastern coast. This Region occupies about 22 per cent of the park's land surface. Three Land Districts have been delineated within the Acadian Land Region:

1. The Deciduous Canyon District is scattered throughout the park in canyons. The slopes are covered with a mantle of colluvial material in which grow varying proportions of white birch, yellow birch, sugar maple and balsam fir-tolerant hardwood forests.

FIGURE 6 CAPE BRETON HIGHLANDS NATIONAL PARK
LAND REGIONS


Neil Harbour
Pres
qu'ile
Broad Cove
Ingonish
Acadian
Boreal
Taiga

2. The Deciduous Slope District occurs along the Park's western coastline. Steep colluvial slopes are exposed to the rigors of the Gulf of St. Lawrence influenced climate. The white birch, yellow birch, white spruce and pin cherry trees which regularly colonize these slopes are normally stunted by the salt spray laden winds.

3. The Atlantic Slope District is the shallow soiled granitic slope of the Neil's Harbour to Broad Cove area of the Park. This district lies below altitudes of 300 meters. Balsam fir, black spruce, jack pine and white pine are dominant species and the ground vegetation is typified by fire influenced bracken.

The Boreal Land Region occupies much of the central and western portion of the Highlands of the Park. In total, it encompasses about 55 per cent of the land surface. The Region is subdivided into the following Land Districts:

1. The Boreal Plateau District is the typical boreal forests of the Cape Breton Highlands. Pure stands of 50 to 75 year-old balsam fir trees grow in the tills of this gently rolling terrain, located in the central and western portion of the Park.

2. The Upper Balsam Fir Valley District is the gently sloped portions of canyons which are characterized by balsam fir dominated forests.

3. The Balsam Fir Ridge District is the series of crescentic granite ridges south of the South Aspy River Valley. Bouldery, shallow soils support open stands of balsam fir, numerous barrens and logs.

4. The Balsam Fir Taiga District is the transition between the Boreal

Land Region and the Taiga Land Region. It is characterized by mature forests of balsam fir on the side slopes of broad hills topped by barrens and bogs. Much of the park's central Highlands is occupied by this District.

The Taiga Land Region generally occurs at elevations above 400 meters. Broad expanses of windswept barrens and blanket bogs characterize this Region.

Two Land Districts form the Taiga Land Region:

1. The High Plateau Mire District is a series of blanket mires scattered throughout the higher elevations. The major and most impressive element is a large blanket mire system located at the headwaters of the Big Southwest Brook. Much of the water storage capacity for rivers originating in the Highlands is the sedge and sphagnum of this district.

2. The High Plateau Barren District is widely scattered and at high elevations in the highlands. Dwarf black spruce, Reindeer moss-Blueberry and stunted black spruce-fir provide the dominant vegetation cover over the deep humic soils.

For each of the three land regions described above, the principal physical and biological base information was inventoried, classified and mapped. The component studies include bedrock geology, surficial material, landform type and vegetation.

An inventory of the land mammals of Cape Breton Highlands National Park was conducted at various levels of intensity from 1974 to 1979. Field studies, surveys and trapping programs supplemented by past studies and information from the literature provided information on the status, distribution and habitat of 40 species of mammals, including two extinct and four hypothetical species. Information on 17 species of marine mammals is also included in this report.

The distribution and abundance of most mammal populations were found to be as predicted from general surveys and reports of mammals of the region. Two small mammal species, the rock vole and Gaspé shrew not previously known to exist in Nova Scotia, were found in the Park. Their nearest known range was in northern New Brunswick and the Gaspé peninsula of Quebec. Snowshoe hares were very abundant during the inventory years. White-tailed deer populations appear to be stabilizing far below previous high numbers while moose have recently been increasing both in numbers and distribution. Evidence of American marten, eastern cougar and coyote was recorded although none of the evidence was confirmed. The recent outbreaks of the spruce budworm in the balsam fir forests has resulted in significant changes in the habitats and populations of some wildlife. Since the inventory program began before major vegetation changes occurred, it will provide valuable baseline information for future comparisons.

The objective of the Aquatic Resources Inventory carried out by the Canadian Wildlife Service in Cape Breton Highlands National Park was to provide reliable baseline data on the freshwater environment in the Park. Because the number of lakes in the Park is large and access to many is difficult, it was felt that the most information could be gained by investigating a representative cross section of lakes. To this end, morphometric and hydrologic data were gathered from as many different lakes as possible. The Aquatic Resources Inventory of Cape Breton Highlands National Park provided the starting point for the investigations by cataloguing the freshwater features of the Park. The Inventory builds from that base by describing the morphometric features of a wide range of the lakes, from small highland ponds such as Benjie's Lake and Fishing Cove Lake, to Warren Lake, the largest and deepest lake in the Park. Morphometric features such as area, volume, depth and shore length are of fundamental importance in gaining an understanding of a lake. Parts III and IV of the selected limnological measurements from lakes and streams in the Park included water temperature, dissolved oxygen concentration, pH, water colour, specific conductance, turbidity, secchi disc transparency, chlorophyll a total phosphorous concentration and dissolved inorganic carbon concentration. The Inventory also provided information on fish distribution and potential fish production in the lakes of the park.

An avifauna inventory of the Park was conducted during the mid 1970's. The resultant annotated list provides a summary of the information available on occurrence and distribution of the bird species observed as of December 1978. The period of occurrence, relative abundance, distribution and evidence of breeding are briefly described for each of the 225 species recorded in the Park.

2.1.4.2 Resource Management Studies

Resource management studies completed or ongoing in Cape Breton Highlands National Park include the following:

Salmon Management Study: The Cheticamp River is presently the only stream within Cape Breton Highlands National Park which supports an Atlantic Salmon population of a size to enable a sport fishery for park visitors. Six other streams, however, exist within the Park's boundaries, which support a small number of salmon or may have some potential to support a salmon run. Since the establishment of the National Park, the salmon angling harvest on the Cheticamp River has been monitored and controlled by Park Wardens. Although the salmon population has remained fairly stable, an intensive study was initiated in 1982 by Park staff with the purpose of determining the natural production potential of the Cheticamp River, the size of its existing salmon run and the number of spawning adults required to realize the river's potential. In addition, the six other streams are being studied to determine their capability to support salmon, and the existence of juvenile and adult salmon.

Pine Marten Studies: The American Marten was once a common fur-bearing animal in Cape Breton, but was thought to be extinct due to excessive trapping and habitat loss due to logging. Studies conducted in the late 1970's related to the completion of a mammal inventory for Cape Breton Highlands National Park indicated that a small remnant population of Marten may still exist on the eastern side of the Park. Further studies by the Canadian Wildlife Service were initiated in 1980 to verify this occurrence and to recommend protective management strategies. These studies are continuing in 1982.

Rare Plants Study: As a result of the biophysical land classification completed for Cape Breton Highlands National Park, it was determined that a number of rare arctic-alpine and boreal disjunct plant species exist in the Park. Some of these species are barely surviving in very specialized niches and could be disrupted by the activities of man. To locate and identify these plants, a resource management study was conducted by a contractor during 1980 and 1981.

During the course of the study, 280 plant specimens comprising 140 species were collected in 30 locations. Sixty-four species of vascular plants found in the Park are considered rare or unusual. Three species and one variety, Rhododendron lapponicum, Arremone parviflora, A. mutifida and Drosera rotundifolia var. comosa were discovered for the first time in Nova Scotia. Approximately 50% of the rare plants are essentially obligate calcicoles, confined to lime-rich sites. Thirty-six per cent of the rare plants are principally arctic or arctic-alpine in distribution, their presence in Cape Breton representing persistent postglacial relics. Where necessary, sites of rare plants will receive special status, protection and management.

Other Studies: Over the years, a variety of resource management studies have been completed in Cape Breton Highlands National Park. Topics covered include forest insects and tree diseases, spruce budworm damage and spread, white-tailed deer and moose populations, waterfowl nesting and wintering, as well as trout management.

2.1.4.3 Resource Description and Analysis

The Resource Description and Analysis for the Park is presently being prepared and will consist of firstly, description and analysis of the resources, and, secondly, the sythesis and evaluation. Park biophysical data is being reorganized into a computer-oriented format to enhance graphics production and facilitate complicated analysis.

2.1.4.4 Natural Resource Monitoring Program

Ongoing resource monitoring projects in Cape Breton Highlands National Park include daily climate monitoring, track transects carried out twice each winter, dead deer survey each spring, a yearly tern survey, exclosure plots measured every second year, an aerial ungulate census carried out every third year, and the measurement of permanent vegetation sample plots every five years.

2.2 Kejimkujik National Park

2.2.1 Historical Background

Native tribes have travelled through and inhabited Kejimkujik for over three thousand years. By the early 1820's Europeans had settled the nearby communities and a few farms were cleared in the area now included in the park. These early settlers mixed farming with lumbering, hunting and trapping to carve out a living. Later, the Kejimkujik wilderness became widely known as a sportsman's paradise. Resorts and cottages offered accommodation and supplied guides to visiting sportsmen and their families. By 1964, when Kejimkujik National Park came into being, both the farming and wilderness resort eras were in decline.

2.2.2 Physical Background and Park Facilities

Kejimkujik is the only completely inland national park in the Atlantic Provinces (Figure No. 7). Despite this, water has a major influence on the park landscape with fully fifteen per cent of the park being made up of freshwater lakes and rivers. It was along these waterways that man first visited Kejimkujik and park facilities have been developed specifically to complement these traditional routes. Canoeing remains the best way to see and experience this national park.

2.2.2.1 Geographical Location and Access

Kejimkujik National Park is a polygonal block of land roughly 24 kilometers east-west and 24 kilometers north-south enclosing an area of 377 square kilometers in southwestern Nova Scotia. The northwestern two-thirds of the Park is located in Annapolis County, the southeastern part in Queens County, and the southwestern portion in Digby County.

The Park is accessible via Provincial Highway No. 8 from Liverpool and Annapolis Royal. Most of the park facilities are located on the northern

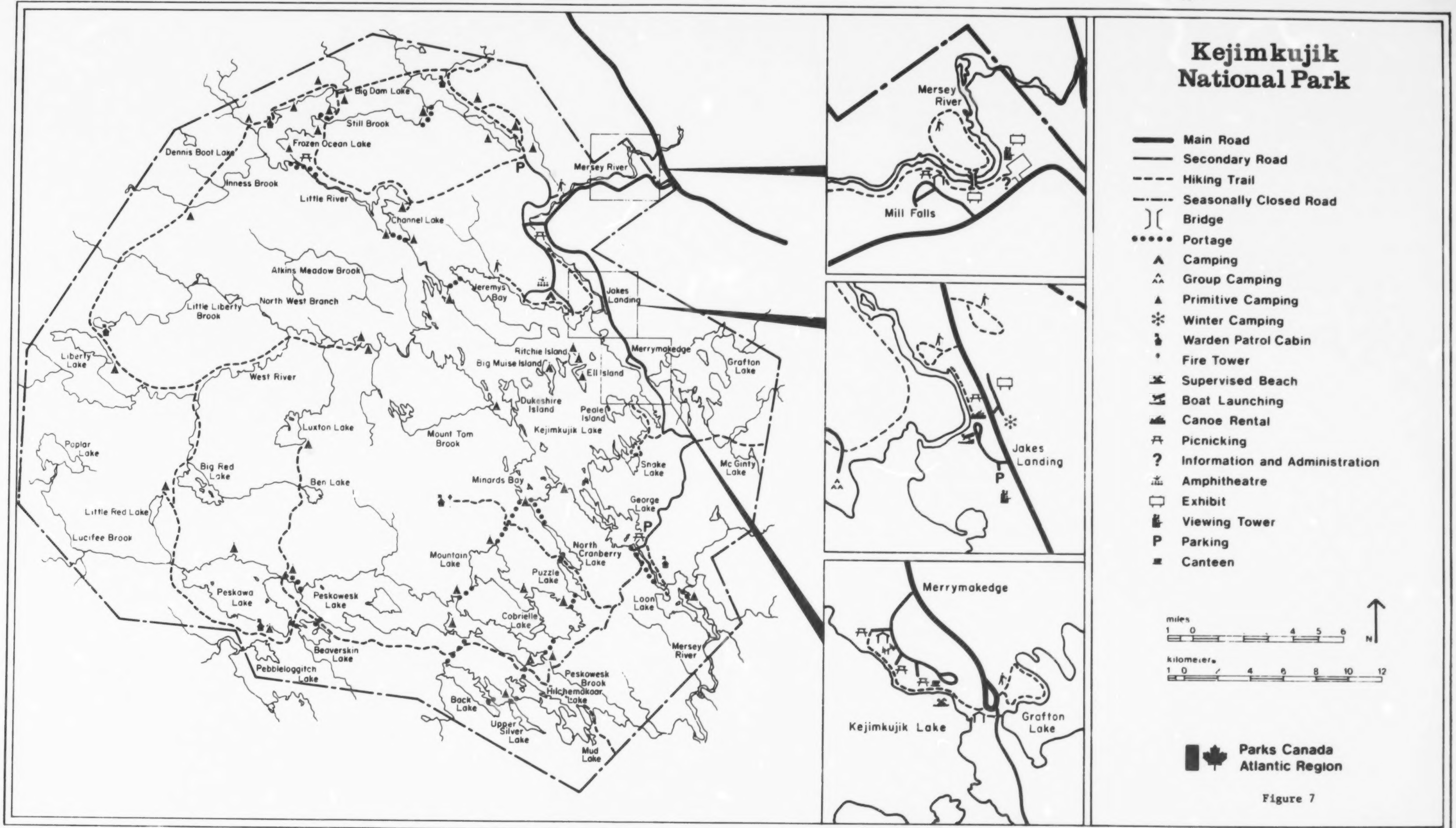

Kejimkujik National Park
Main Road
Secondary Road
Hiking Trail
Seasonally Closed Road
Bridge
Portage
Camping
Group Camping
Primitive Camping
Winter Camping
Warden Patrol Cabin
Fire Tower
Supervised Beach
Boat Launching
Canoe Rental
Picnicking
Information and Administration
Amphitheatre
Exhibit
Viewing Tower
Parking
Canteen
miles
1 0 4 5 6
kilometers
1 0 2 4 6 8 10 12
N
Parks Canada
Atlantic Region
Big Dam Lake
Still Brook
Frozen Ocean Lake
Dennis Boot Lake
Inness Brook
Little River
Channel Lake
Mersey River
Atkins Meadow Brook
Jeremys Bay
Jakes Landing
Little Liberty Brook
North West Branch
Liberty Lake
West River
Ritchie Island
Big Muise Island
Ell Island
Merrymakedge
Grafton Lake
Dukeshire Island
Peale Island
Kejimkujik Lake
Luxton Lake
Mount Tom Brook
Poplar Lake
Big Red Lake
Ben Lake
Minards Bay
Snake Lake
McGinty Lake
George Lake
Little Red Lake
Lucifee Brook
Mountain Lake
North Cranberry Lake
Puzzle Lake
Peskawa Lake
Peskowesk Lake
Cobrielle Lake
Loon Lake
Mersey River
Beaverskin Lake
Pebbleloggitch Lake
Peskowesk Brook
Hilchemakaar Lake
Back Lake
Upper Silver Lake
Mud Lake
P
Mersey River
Mill Falls
Jakes Landing
Merrymakedge
Kejimkujik Lake
Grafton Lake

Figure 7

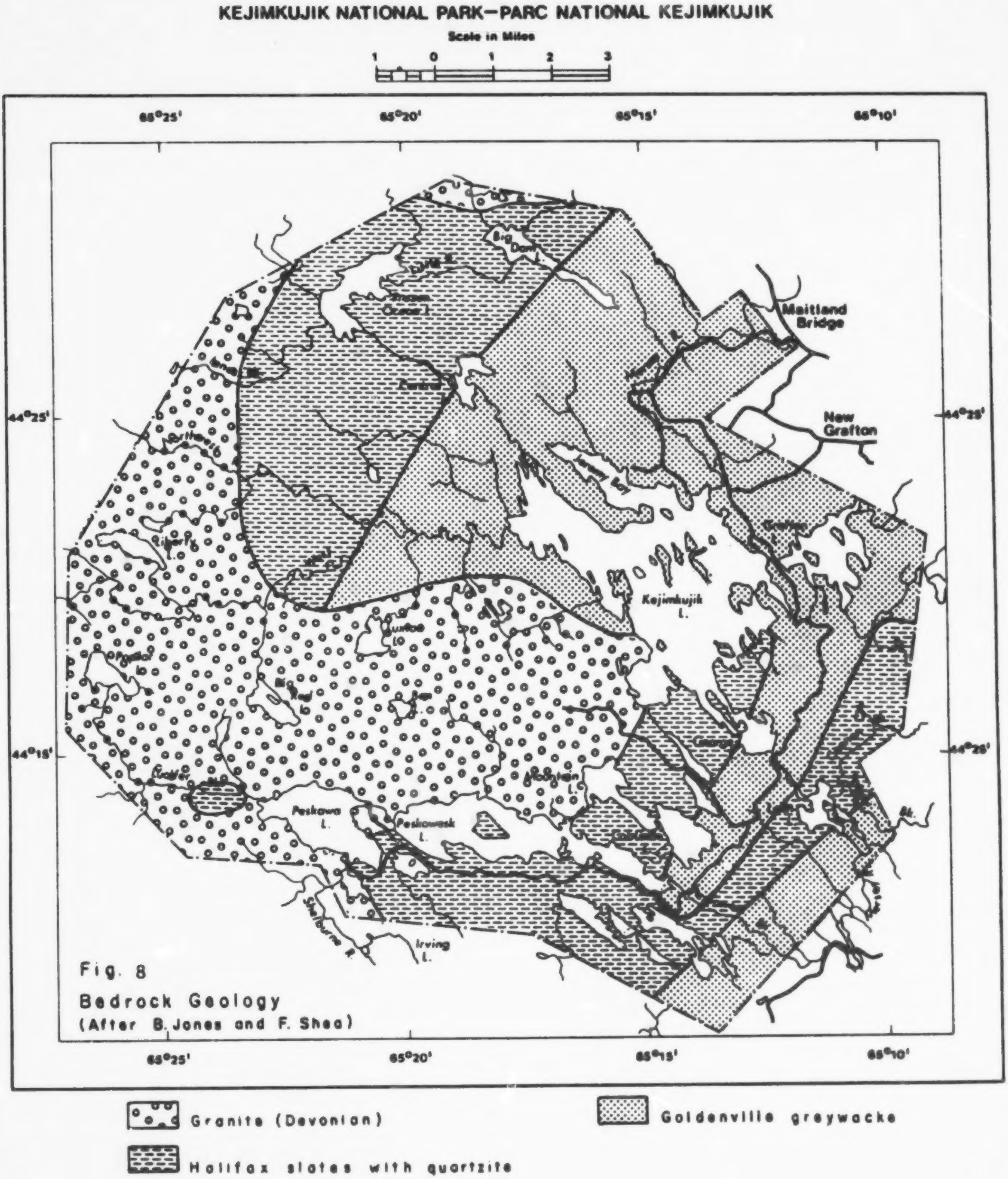
shores of Kejimkujik Lake and access is regulated by the entrance station on the paved park highway branching off from Highway No. 8 south of Maitland Bridge.

A park patrol road extends from the end of the paved road at the Grafton Lake along the southern shores of Peskowesk and Peskawa lakes, with a branch toward the lookout fire tower.

2.2.2.2 Topography

The entire park is in the Atlantic (or southern) uplands of the Nova Scotia division of the Appalachian Physiographic Region. The underlying bedrock consists of intrusive igneous and metamorphic rocks of the paleozoic age, occasionally exposed along the river banks, lakes and road cuts, (Jones, 1965). Massive fine - to coarse - grained Devonian granites underlie the southwestern parts of the park. Light gray and green to black slates, with some interbedded quartzite, occur as the "Halifax formation" in the north around Frozen Ocean Lake and south of Kejimkujik and Peskowesk lakes, while the northwestern portion and the area southeast of Loon and Silver lakes is underlain by greywacke, a dark metamorphic rock of Goldenville formation (Figure 8).

The whole area was covered by ice during the Pleistocene period. As the glacier moved in a southeasterly direction, it modified the preglacial topography and left behind a mantle of glacial drift as till plains and oval-shaped hills or drumlins, indicating the direction of ice movement. The drumlins are concentrated in the eastern parts of the Park where they occur as elongated hills, from 10 meters to slightly over 30 meters high, about one kilometer long and some 300 meters wide, oriented in a general southeast-northwest direction. Some of the glacial material was sorted by meltwater and deposited in glaciofluvial and alluvial landforms such as


KEJIMKUJIK NATIONAL PARK—PARC NATIONAL KEJIMKUJIK
Scale in Miles
1
0
1
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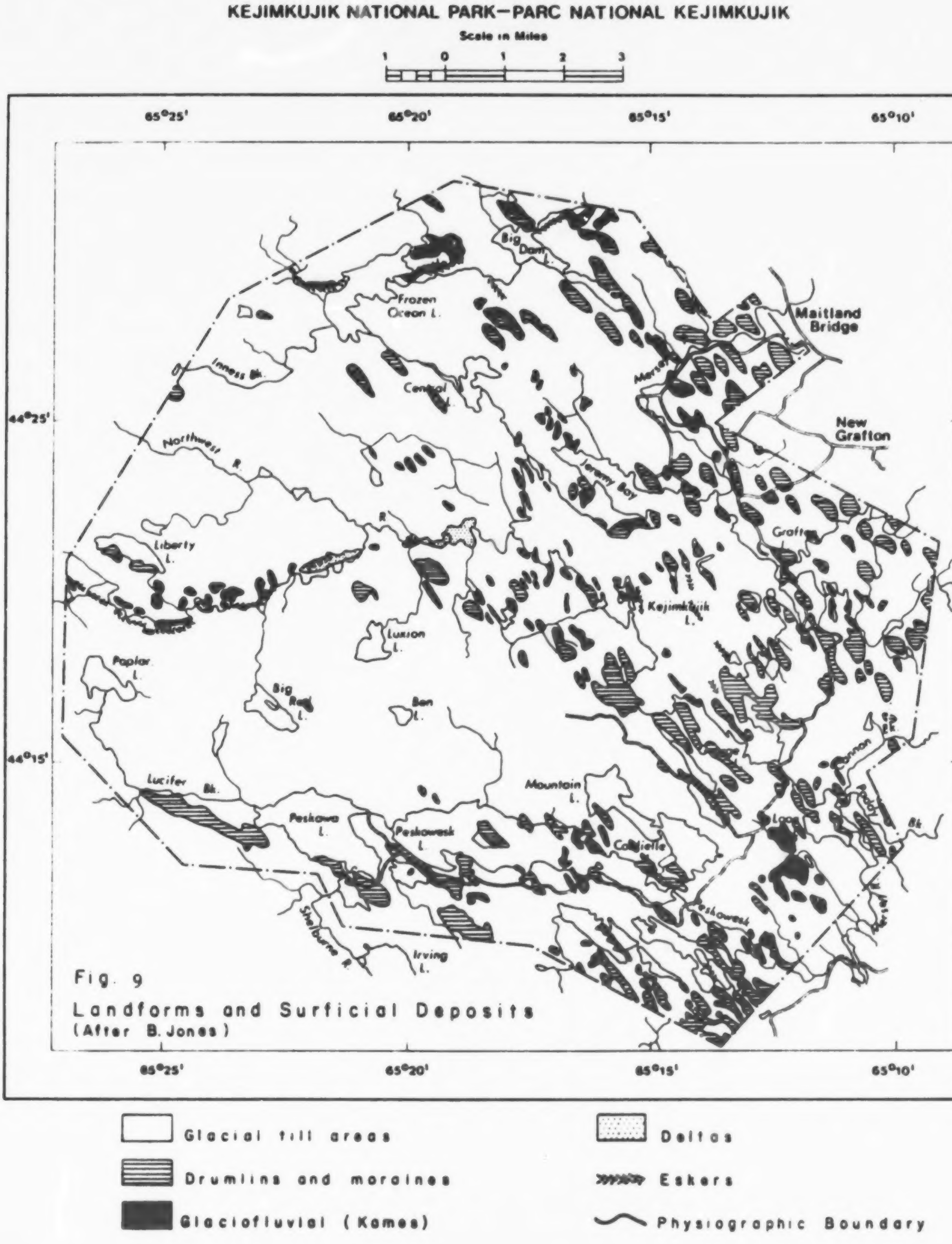
3
65°25'
65°20'
65°15'
65°10'
44°25'
44°15'
Big Dam
Frozen Ocean L.
Maitland Bridge
New Grafton
Kejimkujik L.
Peskowa L.
Peskowesk L.
Irving L.
Shelburne R.
Granite (Devonian)
Goldenville greywacke
Halifax slates with quartzite

Fig. 8
Bedrock Geology
(After B. Jones and F. Shea)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65°10'
44°25'
44°15'
Big Dam L.
Frozen Ocean L.
Maitland Bridge
Inness Bk.
Central L.
Mersey R.
New Grafton
Northwest R.
Jeremy Bay
R.
Grafton
Liberty L.
Kejimkujik L.
Luxton L.
Poplar L.
Big Red L.
Ben L.
Cannon Bk.
Lucifer Bk.
Mountain L.
Peskawa L.
Peskowesk L.
Loon
Cobrielle
Shelburne R.
Irving L.
Peskowesk
Bk.
Glacial till areas
Drumlins and moraines
Glaciofluvial (Kames)
Deltas
Eskers
Physiographic Boundary

Fig. 9
Landforms and Surficial Deposits
(After B. Jones)

outwash plains, kames, eskers and deltas. Recent alluvial and organic deposits occur along the flood plains of modern streams and in numerous depressions occupying former glacial lakes (Figure 9).

The entire park drains into Liverpool Bay via the Mersey and Shelburne River drainage systems. About ten per cent of the park area south of Peskowesk and Peskawa lakes drains into Shelburne River. The remaining 90 per cent of the park is in the Mersey River drainage system, which connects Kejimkujik, George and Loon Lakes as it flows through the eastern portion of the park.

2.2.2.3 Climate

Kejimkujik National Park lies within the cool, humid temperate climate zone resulting from the interaction between the dry continental and the moist, cool Atlantic air masses. The long-term meteorological records from Springfield, Liverpool and Annapolis Royal, located some 40 kilometers from the Park, and the recent six-year data collected in the park indicate that the mean annual daily temperature is 6.1°C with a mean summer temperature of 17.4°C, and -5.0°C in the winter. Extreme temperatures recorded during the period 1966-1973 were -30°C and 33°C. Mean annual precipitation is 1,460 millimeters with 1,208 millimeters of rain and 253 millimeters of snow equivalent.

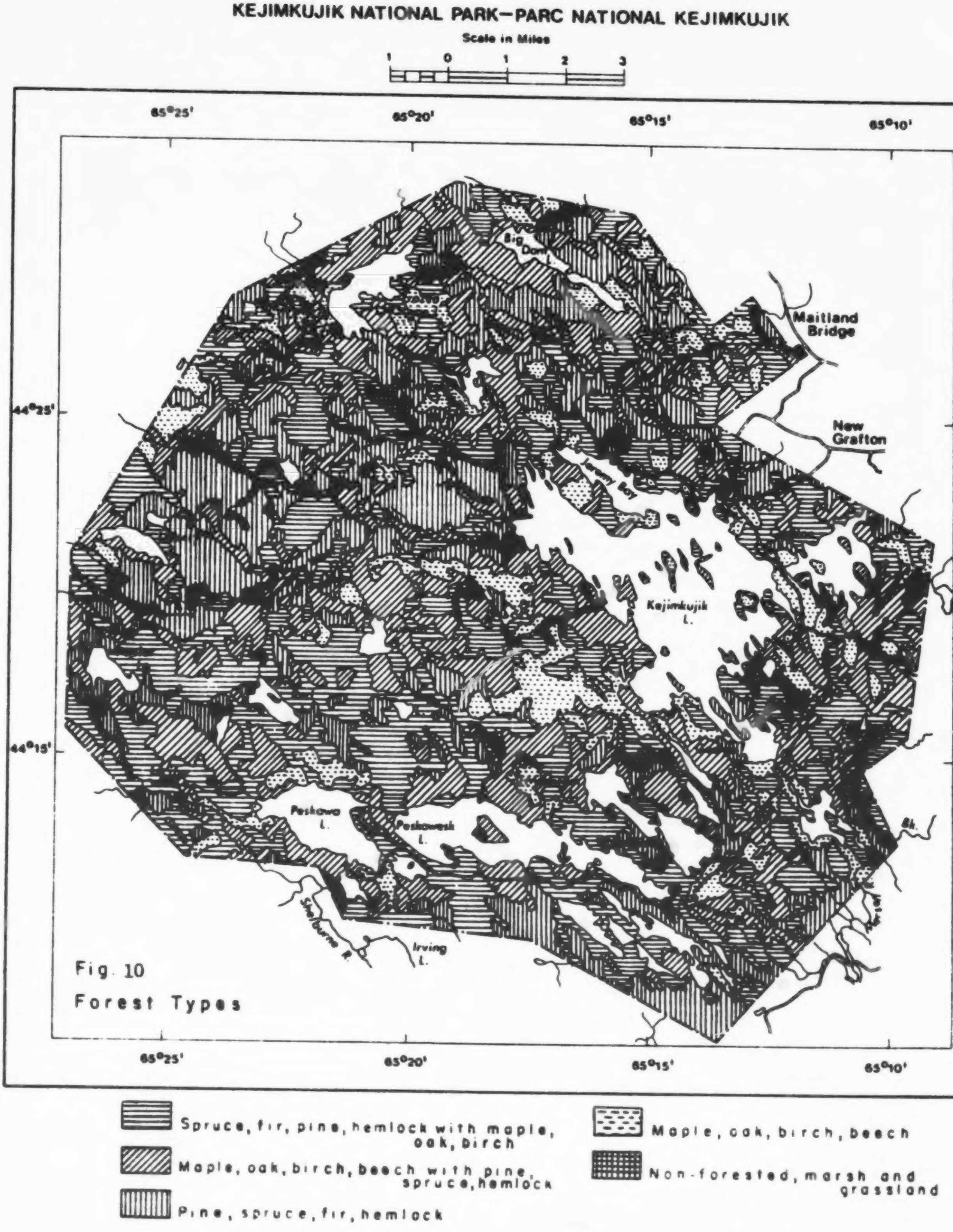
The first snow usually occurs at the end of November and the cover persists until mid-April. An average of 558 millimeters of rain falls during the growing season between the first part of April and the end of September. July and August, with mean daily temperatures of 18°C or more, are effectively much drier because of the increased air temperatures and lower relative humidity. The growing period averages from 170 to 190 days with an estimated frost-free season from 110 to 116 days.

2.2.2.4 Vegetation

The present vegetation resources of the Park, forests and non-forest plant communities have been mapped as components of land types. A total of 14 forest cover type groups and 25 plant associations are involved.

The forests of the Park occupy 30,000 hectares or 94 per cent of the total land area. The entire area is in the Atlantic Uplands Section of the Acadian Forest Region (Rowe, 1972). According to the Loucks forest classification for the Maritime Provinces (Loucks, 1962), the eastern half of the park is in the sugar maple-hemlock-pine zone (Magaguadavic-Hillsborough Ecoregion), while the western half is in the red spruce-hemlock-pine zone (Clyde River-Halifax Ecoregion). The present wide variation in species composition has resulted from past disturbances by logging, forest fires and agriculture. The main tree species are red maple, red oak, white birch, red spruce, black spruce, eastern hemlock, balsam fir and white pine. About 75 per cent of the forests are mixed stands composed of a combination of coniferous-deciduous species. Pure coniferous stands occupy about 21 per cent of the area, and pure hardwood types account for the remaining four per cent. Forest areas of the Park have been divided into the following 14 forest cover type groups:

1. Spruce, larch-red maple
2. Spruce, fir-red maple
3. Spruce, fir, pine
4. Spruce, fir, pine-maple, birch
5. Maple, birch
6. Spruce, hemlock, pine-maple, birch
7. Pine, spruce-maple, birch
8. Spruce, hemlock pine
9. Spruce, fir, pine-maple, oak, birch
10. Spruce, hemlock, pine-maple, oak, birch
11. Pine, spruce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Scale in Miles
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65°25'
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65°10'
44°25'
44°15'
Big Dam L.
Maitland Bridge
New Grafton
Jeremy Bay
Kejimkujik L.
Peskawa L.
Peskowesk L.
Shelburne R.
Irving L.
Spruce, fir, pine, hemlock with maple, oak, birch
Maple, oak, birch, beech with pine, spruce, hemlock
Pine, spruce, fir, hemlock
Maple, oak, birch, beech
Non-forested, marsh and grassland

Fig. 10
Forest Types

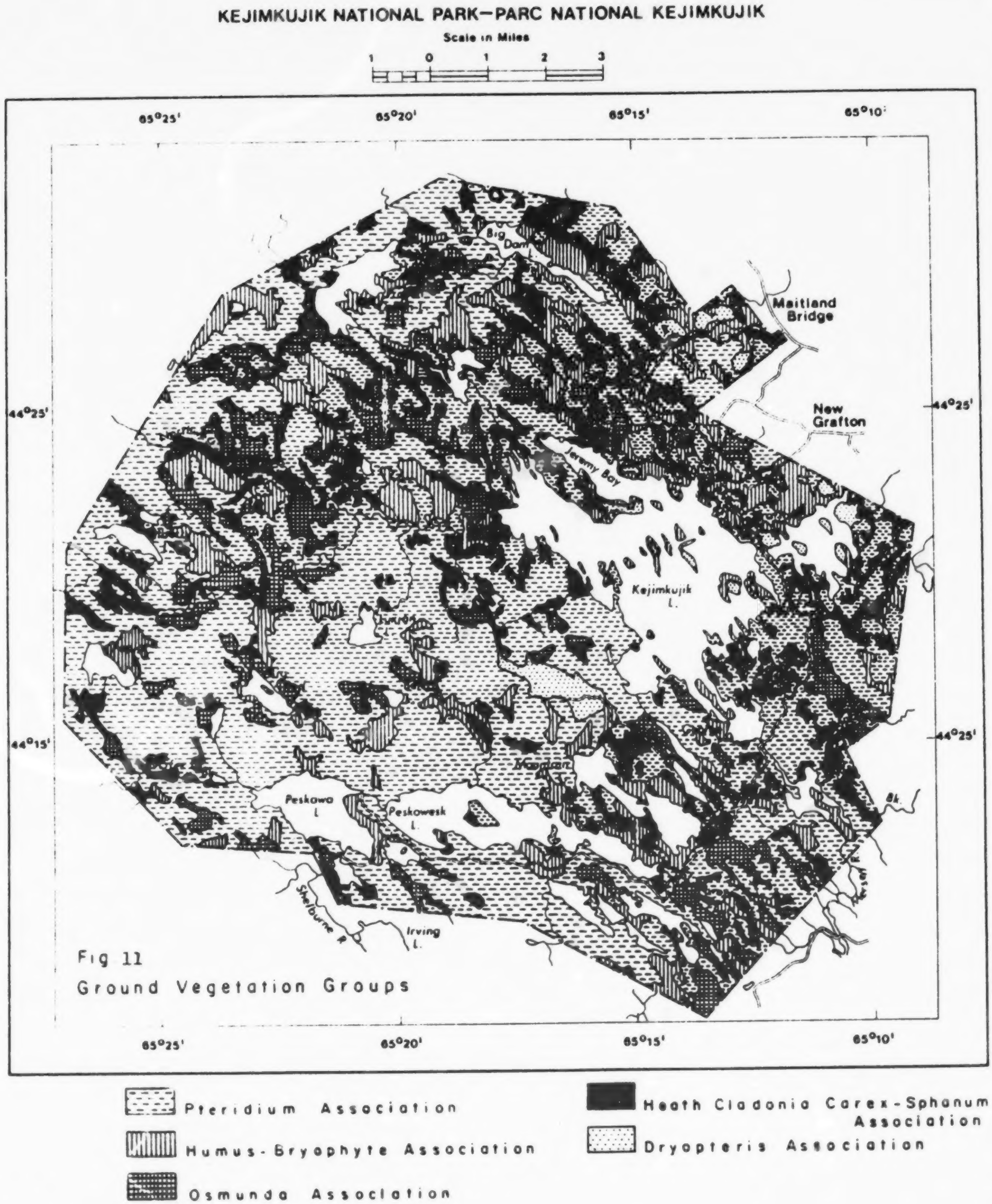
Fig 11
Ground Vegetation Groups

KEJIMKUJIK NATIONAL PARK—PARC NATIONAL KEJIMKUJIK
Scale in Miles
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65°25'
65°20'
65°15'
65°10'
44°25'
44°15'
Big Dam
Maitland Bridge
New Grafton
Jeremy Bay
Kejimkujik L.
Peskowa L.
Peskowesk L.
Shelburne R.
Irving L.
Bk.
Pteridium Association
Humus-Bryophyte Association
Osmunda Association
Heath Cladonia Carex-Sphanum Association
Dryopteris Association

12. Pine
13. Maple, oak, birch-pine, spruce
14. Maple, oak, birch-beech

Non-forest plant communities occurring in forest and non-forest areas were grouped into plant associations. A total of 25 associations of ground vegetation were defined in the park as follows: eight in forested area (sedge-sphagnum, cinnamon fern, Humus-Bryophyte, wood fern, beech, broom crowberry, bracken fern and rock fern) and the remaining 17 associations in non-forested areas (marshlands, bogs, lakeshores, roadsides and abandoned farmland). Generalized maps of main forest types and ground vegetation types are shown in Figures 10 and 11.

2.2.2.5 Fauna

Most wildlife and avifauna populations normally associated with the Atlantic Uplands and typical of eastern Canada are found in the Park, including such examples as white-tailed deer, beaver, black bear, warblers and the common loon. The following mammals are of particular interest because of their rare occurrence: pigmy shrew, hoary bat, red bat, eastern flying squirrel, lemming vole and fisher. The habitats of the northern ribbon snake and the Blanding's turtle, both listed as being rare in Nova Scotia, are also protected in Kejimkujik National Park. The amphibians of the Park include one species of toad, seven frog species and four salamander species, all considered of common occurrence. Recent concerns have been raised, however, that the acidification of Kejimkujik watersheds as a result of man-caused pollution could cause the demise of certain amphibians from affected rivers and lakes.

2.2.2.6 Park Facilities and Services

Visitor facilities at Kejimkujik are designed to provide the visitor with maximum contact with the natural resources. Camping is the only type of accommodation available within the park. Jeremys Bay Campground features 329 semi-serviced campsites in the forest adjoining Kejimkujik Lake. An additional 100 campsites are located throughout the backcountry of the park. Access to the wilderness campsites is by canoe or trail only, while the main campground at Jeremys Bay is serviced by paved roadway. A group campground is available with a capacity of 100 persons.

The visitor to Kejimkujik is provided with a number of opportunities to obtain information about the park facilities and resources. An information office/interpretive exhibit near the park entrance is staffed year round in order to fulfill the needs of the public. Several on-site exhibits and self-guided trails offer opportunitites for the uninitiated park user, while a full-scale interpretive programme presents slide talks at an outdoor amphitheatre. An exhibit trailer, a children's programme and numerous guided walks are available during the summer months for both tourists and local residents. Six picnic areas provide facilities for year-round use. Canoe and bicycle rentals are available in the Park. Merrymakedge, one of the two main swimming beaches in Kejimkujik, features lifeguard service and a small restaurant.

2.2.3 Park Staff Organization

The Park Superintendent, who reports to the Regional Director, is responsible for the day-to-day operation of the park. The five operational divisions, each headed by a manager, are as follows: Administration, Warden Service, Interpretive Service, Visitor Services, and General Works. A sixth park officer, the Natural Resource Management Advisor, also reports to the Park Superintendent. The Park Warden Service consists of a Chief Park Warden, three full-time Park Wardens and one seasonal Park Warden.

2.2.4 Natural Resource Conservation

The approved Park Management Plan (1978) emphasizes that protection of the resource features and the natural processes occurring within the Park is the principal objective to be met by park management. A key element in the park management process is the identification of important resource value areas and the establishment of a zoning plan. The Kejimkujik Management Plan has resulted in the following zoning system:

> Zone I Special Areas encompass 14 square kilometers, and includes: (a) special natural areas, such as outstanding coastal plain habitat, important avifaunal nesting areas and unique forest types; and (b) special cultural features, such as the petroglyphs and other archaeological sites.
>
> Zone II Wilderness Areas involve 293 square kilometers, which is approximately 75 per cent of the Park. They have been established to protect major landscape features and processes in a natural state so that a wilderness experience can be provided to visitors. Major natural features include waterways, glacial features and forest associations representative of the interior of the Atlantic Coast Uplands Natural Region. Primitive developments, such as hiking trails and small dispersed campsites, are provided.
>
> Zone III Natural Environment Areas cover 68 square kilometers of the Park. Included in this zone are areas transitional between wilderness and developed outdoor

recreation areas. User opportunities include picnicking, hiking, bicycling, canoeing, cross-country skiing and on-site interpretation.

Zone IV General Outdoor Recreation areas encompass 7 square kilometers and include the administration building and maintenance compound, the Mill Falls picnic area, the Jeremys Bay Campground, the Jim Charles Point group campground, Merrymakedge Beach and picnic areas, the former fish hatchery, the Conservation Corps camp and Warden housing.

2.2.4.1 Basic Natural Resource Inventory

The basic natural resource inventory of Kejimkujik National Park involved an Ecological Land Inventory completed in 1975. Due to its relatively small size, the entire park was mapped at the land type level. The forest cover and non-forest plant communities were appraised as biotic components of land types.

An inventory of mammals in Kejimkujik National Park was conducted by the Canadian Wildlife Service during 1971 and 1972. The abundance, distribution and habitat preferences of each species was inventoried. A total of thirty-four species of mammals was found to occur within the Park.

An aquatic resources baseline inventory was carried out by the Canadian Wildlife Service in 1974. The lakes, in general, were found to be shallow, warm and poor in nutrients. Twelve species of fish were found to occur, with warm water species such as white perch, yellow perch, and brown bullhead being most common. Two lakes support Lake whitefish populations, which were probably introduced at the end of the 19th century.

An avifaunal survey of Kejimkujik National Park was carried out during 1971 and 1972. The survey inventoried: relative abundance of transient, summer and permanent resident species avifauna, the status of breeding birds, areas of concentration of certain bird species, and habitat relationships of specific bird species. It recommended establishment of a system of permanent sample plots and further investigation on presence of inconspicuous species.

2.2.4.2 Resource Management Studies

Resource Management Studies completed or ongoing in Kejimkujik National Park include the following:

Studies of White-tailed Deer; since 1979, a radio telemetry study on White-tailed deer has been ongoing to determine daily and seasonal movements and habitat usage by selected individuals. A large percentage of the Park's deer population utilize hardwood and mixed wood habitats on the eastern side of the Park, and in particular, areas adjacent to the main Park highway, campgrounds and other facilities. Management implications include the effect of the deer herd on available food sources and forest regeneration, effects of deer hunting on lands adjacent to the Park and the maintenance of a healthy Park deer population. Sufficient telemetry data has now been compiled to enable analysis. In conjunction with this study, an intensive deer browse survey and deer road count survey are conducted annually.

Studies of the Blanding's Turtle; Blanding's turtles and ribbon snakes are isolated populations in the area of Kejimkujik National Park and are the only remnants in Atlantic Canada of once widespread reptiles. (Isnor, 1981) Blanding's turtles are present within an approximate ten-mile radius of Kejimkujik Lake. Studies on the Blanding's turtle have been ongoing since 1970. Information on observations have been recorded, captured individuals have been marked and recaptured and some nesting areas have been identified. Through this work, it is hoped that growth rates, longevity, local migration, causes of mortality, life history and habitat requirements can be better understood.

Pine Marten Reintroduction; the American Marten was once a common fur-bearing member of the weasel family throughout Atlantic Canada, but has been extirpated over much of this region. In 1981, a resource management study was initiated in Kejimkujik National Park to determine the availability of suitable habitat, food and the feasibility of reintroduction. To date, some limitations to a successful population re-establishment have been identified, however, further studies will be conducted.

Other Studies; resource management studies completed to date in Kejimkujik National Park are extensive and varied. During 1977 and 1978, a contractor conducted studies on the effects of visitor use on wilderness campsites, trails, etc. In 1976, a study was completed by Park staff on the potential of reintroducing salmon to the Park. Studies on coastal plain and other rare plants were carried out during the summers of 1975 and 1976. A variety of research has been completed by the Canadian Wildlife Service and other agencies on acid rain and the effects of acidification on limnological conditions. In particular, Park staff are concerned over the potential effects of lowering pH on trout, some other fish species and amphibians.

2.2.4.3 Resource Description and Analysis

The Resource Description for Kejimkujik National Park takes the form of a resource atlas. It is a collation of the most important data on the resource base of the Park. Compiled by Eastern Ecological Corporation in 1976, the Atlas describes such factors as climate, bedrock geology, surficial geology, soils, limnology, vegetation and animals ocurrence and distribution in considerable detail. Human history is also outlined, as are environmental relationships.

The Resource Atlas for Kejimkujik was designed to be updated. Additional base information that results from the ongoing park resource monitoring programme is added to the document.

2.2.4.4 Park Conservation Plan

The 1981-82 edition of the Kejimkujik Conservation Plan identifies fifty-seven concerns. The scope of these concerns is diverse. They include the impact acid rain is having on Park ecosystems and urgent issues, such as the protection of the petroglyphs (Micmac Indian Rock Art) and campground resource managment.

2.2.4.5 Natural Resource Management Plans

Several natural resource management plans presently being implemented at Kejimkujik National Park include the following:

Fairy Bay Petroglyphs: The objective of the Fairy Bay Petroglyphs management plan is to protect these valuable examples of rock art from degrading. Recommendations for action included an accurate recording program completed in 1981 and an examination of erosion factors by Parks Canada conservation specialists. Improved visitor control methods were also recommended, as was continuation of monitoring of the site.

Jeremys Bay Campground: The objective of the campground resource management plan is to provide a high-quality camping experience in a natural setting. Recommendation included measures to maintain indigenous vegetative cover, to optimize visitor safety, to minimize trampling and erosion, to minimize dangerous human-animal conflict, and to prevent and control accidental fires.

Wilderness Campsites: The objective of wilderness campsite management is to preserve a high-quality camping experience which ensures protection of the environment and optimum operational efficiency. Recommendations of the plan resulted in a site rotation strategy, a firewood supply strategy and increased visitor education.

Eel Weir Archaeology - Zone I Area: The objective of this management plan was to protect the archaeological integrity of the eel weir site until salvage and investigative archaeology could be completed. This would ensure that parking lot, picnic site, boat launching ramp and other facilities would not interfere with important resource values. It has been necessary to define archaeological site boundaries more precisely.

2.2.4.6 Natural Resource Monitoring Program

Physical and biological components of the Kejimkujik National Park ecosystem are monitored in an effort both to ensure the Park's resources are being effectively managed and to provide background data to assist in protecting the park. Daily weather records are maintained. Water samples are regularly taken as part of the acid rain related benchmark studies, but also to ensure park waters are being maintained in conditions safe for public use. Soils are tested to detect deterioration of the environment where concentrated visitor use is occurring.

Forest study plots have been established in representative vegetation stands and are surveyed on a five-year schedule. A forest insect survey is conducted by the Canadian Forestry Service. An annual creel census provides the fish management programme with information on fisherman success, fish age class, distribution and growth ratios.

Nesting surveys are conducted for Loons, Greater Black-backed gulls and passerine species. Continuous monitoring of small mammal populations and white-tailed deer also occur.

SECTION 2

CANADIAN WILDLIFE SERVICE

ENVIRONMENT CANADA

BRIEF TO THE NOVA SCOTIA ROYAL COMMISSION ON FORESTRY

VOLUME II, SECTION 2

Meeting the Requirements of Wildlife in Forest Management Programs

CANADIAN WILDLIFE SERVICE

Prepared by:

P. A. Pearce
G. A. Parker

Table of Contents

page

2.1. Foreword 1

2.2. Management of Forest and Wildlife - General Considerations 1

2.2.1 Introduction 1

2.2.2 Balancing the Demands for Forest Resources 2

2.2.3 The Concept of Edge 3

2.2.4 Even-and Uneven-aged Forests 4

2.3. Forest Harvesting 5

2.3.1 Clearcutting 5

2.3.2 Adjusting Clearcutting Practices to Benefit Wildlife 6

2.4. Site Preparation 7

2.4.1 Introduction 7

2.4.2 Some Advantages of Non-scarification 8

2.4.3 Consequences of Scarification 9

2.5. Regeneration 10

2.5.1 Introduction 10

2.5.2 Herbicides 11

2.5.3 Wildlife Damage to Plantations 12

2.5.4 Some Implications of Trends to Conifer Monoculture 12

2.6. Forest Protection with Chemical Pesticides 14

2.6.1 Introduction 14

2.6.2 Assessment of Currently-used Pesticides 14

2.6.3 Mitigative Considerations 15

2.6.4 Cautions and Alternatives 16

2.7. Wildlife of Particular Interest 18

2.8 Conclusion 19

Helpful References 21

2.1. FOREWORD

The invitation of the Nova Scotia Royal Commission on Forestry to Environment Canada to submit a brief did not identify any particular wildlife matters it wished to have addressed in the context of forest management in that province. The Canadian Wildlife Service welcomes the opportunity, nevertheless, to express its views on some implications for terrestrial wildlife of current and potential forest management practices. In doing so, in the following few pages, principles and philosophy are stressed: for the most part, details must be sought elsewhere.

It is worth at the outset repeating the obvious - that natural forests are much more than mere assemblages of trees. They are, rather, complex ecosystems where the lives of fir and fern, budworm and beetle, salamander and salmon, warbler and woodpecker, mink and moose all in some way impinge on each other and contribute to the harmony of the whole in a dynamic, constantly changing way. Man himself, not apart from the forest, has the power of exerting a benign or harmful influence there, whether it be preserving a stand of rare orchids, or clearcutting an entire water catchment basin. Although far from being fully understood, enough is known about the interrelationships between living things in the forest that multiple use of its many renewable resources may be enjoyed in ways compatible with maintenance, indeed enhancement, of the social, including economic, well-being of man and the ecological integrity of the forest.

2.2. MANAGEMENT OF FOREST AND WILDLIFE - GENERAL CONSIDERATIONS

2.2.1 Introduction

Forest management is the process of manipulating the forest environment to produce a mix of products desired by the owners. The kinds of products change with time, economic conditions, public demand, legislation and capability of the land. In eastern Canada the forest resource currently in greatest demand, and to the production of which most forest management programs are directed, is softwood fibre for manufacture of paper and related materials. Softwoods are also sought for building purposes and many other activities, but the management of forests for trees to feed the pulp and paper industry is of greatest concern and some of its impacts are the focus of this submission.

In most managed forests, wildlife habitat is a by-product of timber management. Growing public demand for accelerated production of fibre and other wood products has been accompanied by expanded recreational needs and calls for allocation of more wilderness areas. Forest management practices undertaken to enhance wood production normally cause dramatic changes in wildlife habitat. The opportunity for terrestrial wildlife management on a large scale stems from the manipulation of forest vegetation primarily for wood production. But timber management *is* wildlife management. The degree to which it is *good* wildlife management depends, however, on how well the forester can be persuaded to manipulate habitat to achieve the wildlife biologist's objectives. If correctly planned and executed, timber management procedures are potentially the most practical way to achieve quality and diverse wildlife habitat in the forest landscape.

2.2.2 Balancing the Demands for Forest Resources

How is the forest manager to balance the demands for renewable forest resources, including wildlife, and still maintain a sustained yield of wood products? How can the disparate needs of a diverse range of wildlife species be considered? There are two basic conditions which must be understood and accepted, upon which regulations and guidelines must be based. First, it is essential that the forest manager, the wildlife manager, the field forester and the wildlife biologist work closely together. Second, although general forestry-wildlife management principles are understood and guidelines available, each individual site is characterized by specific biotic and edaphic conditions, and integrated forestry-wildlife management plans must recognise those site-specific characteristics. Once those conditions are fully appreciated and incorporated within provincial and regional management policies, integrated forestry-wildlife management programs can begin.

With the advent of intensified forestry management, the wildlife manager can no longer afford to maintain a low profile two steps behind his forestry counterpart. He can no longer be content to accept whatever benefits for wildlife may unintentionally accrue from the single resource, wood-fibre-orientated forest management philosophy. Neither can the forester continue to meet his professional obligations, in the broadest sense, while ignoring growing societal demands for forest wilderness resources other than trees. Integrated management must mean more than satisfying the requirements of and for "game" species. It must embrace all forest animal species, for the demands of the non-consumptive user of wildlife are already greater than those of the consumptive user, such as the hunter.

2.2.3 The Concept of Edge

Wildlife management is the scientifically based art of manipulating habitat to enhance conditons for a selected species or manipulating animal populations to achieve other desired ends. It implies both the technical ability and the managerial flexibility to substantially influence habitat, or animal populations, or both.

The juxtaposition of plant communities, successional stages, or stand conditions within communities produces edge. Edges represent rich habitat for wildlife because they have attributes of the edge itself plus those of the adjoining communities or successional states. Many herbaceous plants, butterflies, birds and mammals dwell at the forest edge. Increasing the amount of edge increases habitat richness, which is a measure of the number of wildlife species resident within an area. A forest with a high degree of diversity of communities and successional stages provides habitat for a wide variety of wildlife. Any change in forest structure or composition will favour some wildlife species while adversely affecting others, influencing the number and kind of wildlife species and their use of habitat.

2.2.4 Even- and Uneven-aged Forests

Timber management basically is the husbandry of either even-aged or uneven-aged forests. Management of uneven-aged stands by selective cutting tends to produce blocks of continuous cover dominated by relatively mature trees. It benefits wildlife species adapted to more mature forest conditions, and it can be used to preserve the integrity of delicate and disproportionately important wildlife habitats, such as riparian zones. The objective of even-aged timber management is to maintain a forest comprising stands each with little or no differences in tree ages. Harvesting of even-aged forest by clearcutting produces distinct successional stages and a high degree of horizontal diversity because there are numerous stands of various age classes scattered through the forest, producing a variety of habitats.

No single system of forest management can meet the objective of those concerned with maintenance of wildlife in abundance and diversity. The decision about which system to use must be based on specific wildlife management goals. Flexibility in the use of silvicultural systems can be a key to meeting a range of wildlife goals, each decision having some consequences for wildlife.

2.3. FOREST HARVESTING

2.3.1 Clearcutting

The forest industry in Nova Scotia, similar to that in other regions of Canada, is concerned with harvesting the most timber from a unit area in the shortest possible rotation at the least expense. It frequently means managing for even-aged stands of conifer or mixed wood stands on large tracts of land. The universal practice of clearcutting in Nova Scotia is not likely to be replaced by some less economical method of timber harvesting. The key to successful regulation of timber age classes for combined timber and wildlife production, at minimum cost and maximum timber yield, is the long-term planning of cutting schedules for small units of land.

Over the past 20 years the use of a wide array of mechanical tree harvesters and handlers has made it possible to greatly expand production and the size of individual clearcuts. Mechanization of harvesting operations doubtless will continue, with increased capability of production (demand) placing further pressure on timber inventory (supply).

The requirements of wildlife must somehow be constantly addressed as wood harvesting expands. Since forest harvesting is the single most important tool at the disposal of the wildlife manager, the optimist might regard the present era of intensified forest management as an unprecedented opportunity for the implementation and development of wildlife management programs. The pessimist might only see the steady loss of mature trees as another example of mankind's orderly march to self-destruction. Cautious optimism should, perhaps, be the watchword.

2.3.2 Adjusting Clearcutting Practices to Benefit Wildlife

The major impact of intensified mechanical timber harvest is the size, shape and juxtaposition of individual clearcuts. Clearcuts designed to produce maximum edge will attract most wildlife. Besides being of aesthetic value, irregularly-shaped openings provide the most edge. There are, of course, species-specific minimum and maximum limitations on the amount of edge and the size of clearcuts. Large clearcuts may provide sufficient food (e.g. young post-cutting deciduous trees and shrubs) for hares, deer or moose, gamebirds and some songbirds but due to lack of cover (mature or secondary growth of conifers) those benefits may be realized only near the periphery where the cover of adjacent mature forest is available. That is particularly true in the winter.

Riparian strips should be left along even the smallest streams to accommodate the secure movement of wildlife, frequently attracted to such wet areas. Greenbelts between clearcuts are important, but when does their value decrease relative to the developing clearcut? When can greenbelts be removed? How wide should they be? Such questions must be addressed at the regional level between forester and wildlife biologist. Both must be familiar with the area concerned. At that level, general policies become guidelines only. Specific management recommendations must be developed regionally to address the regional situation. There is, for example, little reason to manage for lynx in southwestern Nova Scotia or fisher on Cape Breton Island. Extreme snowdepths on the highlands of Cape Breton Island dictate that food supply of hares, deer and moose would not be utilized in the centre of large cuts; either the food would be covered with snow or be beyond species-specific, maximum threshold distance from cover.

Residual trees are often left standing following clearcutting by many operators, and such practice should be encouraged. Residual trees may be undesirable deciduous species or commercial trees which are inaccessible or of unacceptable quality. These "snags" and den trees are often very important to various cavity-nesting species (e.g. woodpeckers, swallows, buteos,) and many birds may use them for feeding. Den trees are used by a variety of birds and mammals as well as honey bees. The use of tree crushers to prepare clearcuts for the planting of nursery stock will often result in the removal of such trees and denial to wildlife of all the benefits they provide.

Erosion caused by cutting on steep slopes or by faulty location, construction and maintenance of extraction roads may degrade water quality in the vicinity and reduce populations of fish-eating birds. Apart from the obvious problems created by erosion, over-extensive cutting could affect the level of the water table and have adverse impacts, for example, on the production of waterfowl in beaver impoundments, or may thwart attempts to manipulate water levels for the production of waterfowl and other wildlife in adjacent or nearby wetlands.

In summary, clearcutting is the most economical and commonly practised type of forest harvesting in Nova Scotia. The forester and wildlife biologist must arrange the cutting of forest stands to provide optimum benefit to wildlife while minimizing losses to the forest industry. Species and populations can be manipulated by appropriate cutting schedules. The professional forester and the wildlife biologist must assume responsibility for those schedules.

2.4. SITE PREPARATION

2.4.1 Introduction

Site preparation refers to the frequently-required mechanical disturbance, or scarification, of recently cutover forested land with the intent to mix the slash, humus layer and expose mineral soil. Such treatment normally promotes the growth of seedlings, especially nursery stock, but there are many different ways of site preparation in use today. A wide variety of machines is available to the forester and the use of each has its proponents and critics. Each site is unique and should be carefully examined before long-term physical damage is inflicted which would hinder vigorous forest regeneration.

2.4.2 Some Advantages of Non-scarification

The slash, stumps and litter remaining behind a timber harvesting operation represent immediate habitat for a variety of small mammals and birds. Cones, seeds and insects become immediately available to ground-dwelling animals and the debris provides excellent cover for mice, voles and shrews. The same benefits are bestowed on a variety of birds which prefer open habitat for breeding.

An unscarified cutover also produces a rich early successional "bloom" of grasses, forbs, raspberry and the sucker growth of deciduous trees (e.g. white birch, red and sugar maple and pin cherry) as well as a variety of shrubs such as dogwood, blueberry and elderberry. These rapidly growing pioneer species become food for deer, moose and snowshoe hare. If forest cover is nearby, the advantages to herbivores contine through the winter.

Most naturally regenerating cutovers are analogous to regenerating sites resulting from fire or other natural disasters. Such areas which support seral plant communities have traditionally supported a greater abundance and diversity of mammal and bird life than the closed conifer forest. The pre-European North American climax forest was represented by a vast expanse of closed coniferous stands frequently broken by small areas supporting rich animal and plant communities. Breaks in the closed forest, representing developing plant communities of various ages, provided the edge effect important, as we have stressed, to many forms of wildlife.

2.4.3 Consequences of Scarification

The immediate impact of site preparation upon wildlife is negative. Intense scarification eliminates the availability of most of the post-cutting debris. Where large tree-crushers are employed, residual trees are rolled over and ground into the soil, along with the brush, slash and stumps. Such intensive mechanical disturbance may create a favourable environment for growing trees but restricts the use of such areas by many forms of wildlife. Although grasses and shrubs will invade these areas, which may soon appear green, their value to wildlife has been decreased. No residual snags or den trees remain and the removal of cover provided by cutting debris limits use by small mammals and ground-nesting birds. Low numbers of prey species obviously influence the use of such sites by predators, and the reduced supply of deciduous browse restricts their value for the larger herbivores.

In short, site preparation following cutting is a proven method in silviculture which normally promotes the growth and successful development of tree stock, especially nursery seedlings. Caution should be exercised to avoid over-scarification which may lead to erosion, long-term damage to the organic soil component and decreased soil fertility. Consideration should be given wildlife species by allowing some residual deciduous and softwood trees to stand rather than completely denuding the cutover site. Whenever possible, some brush and slash should be left. A site preparation plan addressing the needs of wildlife should strive for diversification of the landscape. It must be emphasized again that each site should be appraised by the regional biologist and provincial or company forester, and plans should be based on its particular characteristics.

2.5. REGENERATION

2.5.1 Introduction

In many areas, artificially created openings in the canopy may soon fill with prolific regeneration of a species not highly desirable - balsam fir. The planting of scarified cutovers with nursery seedling stock of other species is rapidly becoming one of the most universally accepted silvicultural methods. Plantations allow the forest manager to control the composition and intensity of stocking. Most clearcuts by the larger companies are now stocked with trees from private or government nurseries. The threat of the spruce budworm discourages promotion of the regeneration of balsam fir. Common plantation species are black spruce, white spruce, jack pine and red pine. Plantations make good forestry sense, at least in the short term.

Plantations may not resemble the original forest cover. In the northern mixed Acadian forest, the climax forest supported such deciduous species as yellow birch, beech, sugar maple and oak and conifers such as white pine and hemlock. Once removed, the regenerating forests changed to a fir-spruce dominated sub-climax type which is now generally accepted as the mature forest. The original mixed Acadian forest may not be seen again.

Following timber harvest and prior to the appearance of a conifer-dominated mature forest, the normal path of succession begins with a rapid growth of raspberry, shrubs and deciduous tree growth. Conifer seedlings become established but growth is slow under a thick summer mantle of deciduous foliage. The deciduous trees, especially the birches and maples, grow rapidly and after 20-30 years reach pole size. The conifers (spruces and firs) are then developing rapidly and soon break through the canopy. The shade intolerant birches and maples become fewer until, after 75-100 years, the sub-climax mature fir-spruce forest becomes established. If left alone - for how long is questionable - the original deciduous species of the Acadian forest might become re-established. However, long before then the forest is usually harvested again and the cycle begins anew.

2.5.2 Herbicides

Contemporary forest management is committed to reducing the cutting rotation and improving yield. The most obvious way to the forester to ensure maximum rates of seedling survival and growth, is to suppress the rapid growth of early successional stages of dominant deciduous trees and shrubs. Through the use of nursery stock and the suppression of deciduous competition, often accomplished with one or more applications of herbicides, cutting rotations can be shortened by one-third to one-half.

Forest management in eastern Canada currently seems to require an increasing use of chemicals, be it insecticides to preserve green leaves on conifers, herbicides to remove competing broad-leaved species, or fertilizers to promote increased volume growth. Herbicides are strong agents of habitat change - either in the area where employed or, through drift and runoff, in adjacent ecosystems. At present it is the ecological effects rather than the potentially toxic effects on animals that are of interest. We should be on guard against contamination of wetlands where the ecological effects of herbicides may be progressively greater through successively higher trophic levels, as has been demonstrated in the Prairies. We should also be aware of the possibility of direct or indirect toxic effects on wildlife of the newer forest herbicides as they come into commercial use, remembering that registration of a use pattern is no guarantee that problems will not emerge after prolonged and widespread spraying of such herbicides. Assurance is also needed that in each particular situation other, non-chemical methods of vegetation management are not as effective and economically competitive.

2.5.3 Wildlife Damage to Plantations

Certain forms of wildlife damage plantation stock. Promoting the interspersion of wildlife within plantations may not be compatible with the objectives of maximum wood fibre production. During peaks in snowshoe hare abundance considerable damage can be inflicted upon young nursery stock. Deer and moose may also damage young trees but they usually avoid spruces and pines. Voles and mice may nip the buds and girdle small seedlings. Elimination of hardwoods within plantations often reduces their use by herbivores. Total elimination is seldom successful, and varying amounts of wildlife food normally remain. Thus few plantations are devoid of wildlife.

2.5.4 Some Implications of Trends to Conifer Monoculture

What are the direct and indirect implications for wildlife of this approach to forest regeneration? Perhaps the most serious long-term impact on the forest ecosystem from suppressing deciduous species and encouraging conifers is the decline in soil fertility. The early period of successional deciduous growth serves to build an organic humus layer which increases soil fertility. Eliminating that period of rejuvenation will eventually lead to acidification and a reduction in the ability of the soil to support forest growth. Such a change would be fundamentally detrimental to the health of both plants and animals.

The more direct impact upon wildlife by "coniferization" of the forests is one of habitat change, or habitat elimination. The loss, or suppression, of deciduous trees and shrubs which provide food and cover will affect many wildlife species, often negatively. There are innumerable examples of how vitally important deciduous-dominated successional forest communities are to many forms of wildlife. Any effort towards reducing those seral stages in forest development would have a pronounced impact upon dependent animal communities.

But how serious is that threat to wildlife when considered on a provincial level? At present, the threat appears to be minimal, and should remain so in the foreseeable future. The total amount of forest land presently under the form of management described is still small, and, although projected growth is impressive, the total area involved will be minimal province-wide. However, the potential long-term negative effects on the environment of a management policy aimed at monoculture forest, with its relatively poor biotic diversity, must be seriously considered and incorporated into long-term strategies. Intensively-managed, monocultural conifer plantations share similarities with agricultural and horticultural systems. Their potential instability raises the concern that their protection may require an increasing use of chemical pesticides. Indeed, the first manifestation of that phenomenon has already been noted in Atlantic Canada.

2.6. FOREST PROTECTION WITH CHEMICAL PESTICIDES

2.6.1 Introduction

To maintain optimum productivity, forests must be protected against a variety of enemies including noxious insects. One aspect of forest management that has become particularly controversial is protection through the use of chemical pesticides. Aerial application of insecticides to forests began, in Canada, in 1927. Calcium arsenate was then dusted on one thousand hectares of Nova Scotia against a familiar pest, the spruce budworm. In 1976 complex organic pesticides were sprayed over four million acres of fir-spruce forest in New Brunswick against the same insect. There were reports of wildlife casualties in both operations. Today there remains considerable reliance in forest protection in northeastern North America on synthetic chemical pesticides which have very little specificity and which are totally alien to the natural environment.

2.6.2 Assessment of Currently-used Pesticides

Aerial spraying investigations in the eastern Canadian fir-spruce forest have shown the relative hazard to songbirds of the prime DDT-replacement insecticides to be phosphamidon>fenitrothion>aminocarb. It is encouraging that that is the sequence in which they have been employed. There is wide agreement that the organophosphate phosphamidon should be retired as a spruce budworm larvicide because of its unacceptably high toxicity to birds. The minimum impact of fenitrothion, another organophosphate, has been determined to be a reduction in fledging weights of birds, a phenomenon noted in operational spray zones and also experimentally induced by oral dosing of nestlings *in situ*. Such sub-lethal effects may be common in exposed birds. At the other end of the impact spectrum, the history of fenitrothion spraying in New Brunswick has been associated with sporadic songbird mortality. Birds that forage in the forest canopy were the most vulnerable. Experimentation in the field has shown that any substantial increase in exposure to the spray results in significant adult and nestling mortality and marked decrease in reproductive success. Although the implications could be serious, it has not been possible to determine the long-term influence of such impacts on bird populations. A number of errors in delivery of insecticide over the target could increase local exposure, e.g. maintenance of spray aircraft speed, altitude and echelon integrity, and correct line placement, orientation and realignment. Overswathing is the commonest difficulty we have noted. In the context of operational spruce budworm larviciding with fenitrothion in New Brunswick, the margin of safety to exposed songbirds is narrow, the threshold of acutely toxic effects occurring between once and twice the conventional dosage rate.

Aminocarb, a carbamate insecticide also anticholinesterase in mode of action, is about equally toxic as fenitrothion to a wide range of animals. An advantage is that recovery from exposure to a carbamate is usually more rapid than to an organophosphate insecticide. Of greater significance is that aminocarb is registered for use against spruce budworm at a substantially lower dosage rate than conventially prescribed for fenitrothion. It should be safer for birds and, indeed, extensive monitoring and research have failed to reveal any unacceptable wildlife effects following its use in eastern Canadian forests. At dosage rates at present prescribed for spruce budworm suppression, aminocarb clearly should be preferred to fenitrothion - that is if chemical pesticides must be used at all.

2.6.3 Mitigative Considerations

The following considerations should be borne in mind once a decision has been reached to launch a protection operation using chemical pesticides, so that wildlife impacts are mitigated:

the smallest dosage rate of pesticide active ingredient should be applied, commensurate with goals of insect suppression or foliage protection, or both;

all other spray formulation components should be environmentally benign;

delivery technology should be such that the prescribed emission dosage is not exceeded anywhere in the target forest and that contamination of adjacent ecosystems is reduced to a minimum;

sprays should be applied as early as possible in the spring before the peak of bird migration;

animals may be more vulnerable at times of stress, such as when food is short or during migration or the period of reproduction;

spraying in the evening when most birds are relatively inactive should be preferred to morning spraying;

ecologically sensitive areas within, adjacent to or near the target forest should be identified during the spray permit review process and ways sought to avoid them; and, most importantly

detailed spray plans should be routinely reviewed by regional wildlife biologists thoroughly familiar with their districts so that potential problem areas can be identified early and spray tactics adjusted appropriately.

2.6.4 Cautions and Alternatives

In view of the complexity of the natural forest ecosystem and the inherent risk of deliberately introducing substances broadly toxic by design, legitimate concern about harm to the environment will remain. Despite the safeguards provided by the processes of pesticide registration and spray plan review, there is no room for complacency. Pesticide ecology is notorious for its surprises, a maxim that should be constantly borne in mind. Initiation of an extensive, long-term insect suppression program using chemical pesticides should not be contemplated where options are still fully open, although there could be a minor role for such toxins. One lesson that we should have learned over the last three decades is not to put too much reliance on chemical pesticides. World-wide attempts to control pests on cotton and rice and disease vectors have been vivid illustrations that dependence on extensive and continued use of pesticides can be counter-productive. In the meantime, advances in spraying technology which result in pesticides being used more effectively and environmentally safely are applauded. Finer tuning of the spray apparatus should permit treatments to be tailored to smaller aggregations of forest, close attention being paid to forest type and management objectives and environmental sensitivity of the target and adjacent ecosystems. The considerable effort being directed to attempts to bring the various alternative, so-called biological control methods to operational status is commended. They could include forest cutting. It could be reasoned from an ecological viewpoint that, in dealing with indigenous defoliating forest insects, the best strategy would be to adapt to the ecosystem's dynamics rather than to force it into a different pattern, to adjust management practices to accommodate the damage done by the pest. Techniques of forest protection including extensive cutting would be preferable to widescale use of chemical pesticides.

If the many technical hurdles could be overcome perhaps the long-term strategy for protecting the forest should involve many tactics appropriate to each individual situation. Such integrated pest management has been described as "a systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications and, when necessary and appropriate, chemical pesticides." Its implementation would be curiously appropriate in Nova Scotia where, in the horticulture context, the philosophy of integrated pest management was conceived and nurtured.

2.7. WILDLIFE OF PARTICULAR INTEREST

Cutting and other forestry practices may adversely affect habitat critically important for some forms of wildlife. There seems to have been no official declaration of wildlife species considered to be "rare and endangered" in Nova Scotia. There is, however, general consensus on which animals are scarce in the province and on those which for other reasons deserve special consideration. The interplay of very many factors determines why in a given region populations of some species may be on the wane while those of others are on the increase. Some areas are relatively intimately known, the status of some animals being best understood in the National Parks where intensive faunal inventories are undertaken.

Two examples of wildlife deserving particular attention will suffice. The marten has declined over much of its range in North America, perhaps through destruction of its preferred habitat, mature coniferous forest, or overtrapping, or both. A small population may remain in Cape Breton Island where attempts should be made to encourage its expansion. The spruce budworm may, however, be a critical factor in the marten survival equation. Cape Breton Island also supports what is probably the largest breeding population of Bald Eagles in northeastern North America. It is considered to be endangered in New Brunswick.

Since the birds nest repeatedly at or near traditional aeries, the whereabouts of many of which are known, populations can be relatively easily monitored and special attention paid to maintenance of optimum habitat at and near the sites. The point is that regional wildlife biologists are often best equipped to judge the local status of wildlife, rare or otherwise, and the likelihood that proposed forestry activity in the area would enhance or lessen the animals' prospects for survival. Because maintenance of wide biotic diversity is important, such professionals should be consulted in forest management planning.

2.8. CONCLUSION

The promotion of a monoculture softwood forest management program through the proliferation of conifer plantations and the suppression of deciduous early successional species has several short- and long-term ecological implications which must receive serious consideration.

The short-term influence of the trend to conifer monoculture on most forms of wildlife will be negative but because plantations are limited in area and will continue to represent only a small portion of the land surface of the province the total impact should be minimal. A policy to ensure the interspersion of deciduous or mixed-forest stands among plantations could actually benefit wildlife.

The effect of decreased soil fertility from prolonged support of softwood trees may be of more serious concern in the longer term. However, through a policy of crop rotation where the fertility of a unit of land is maintained by alternating stands of deciduous and conifer trees, the problem could be minimized or avoided completely. The mixed crop system has proven to be the most environmentally acceptable approach in commercial farming. The kind of forest management we have discussed is really commercial tree farming.

Crops must be protected. As far as a strategy of protection against insect pests in concerned, history shows us that commitment to long-term and widespread spraying of chemical pesticides would be imprudent. Rather, the principles of integrated pest management need to be embraced, a variety of biological techniques being used to suit each situation, the role of chemical pesticides being relegated to, at most, a minor one.

We return to the need for integrated forestry-wildlife management planning at the regional level. The interspersion of plantations, relic mature conifer and deciduous stands and successional deciduous and mixed-wood stands must be brought about at the regional level.

The trees should not obscure our view of the forest. In a spirit of cooperative adventure, the forester and the wildlife biologist together can ensure that at least some of the economic and spiritual needs of Nova Scotians and the requirements of Nova Scotian wild fauna are optimally met, now and in posterity.

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SECTION 3. ENVIRONMENTAL PROTECTION SERVICE

ENVIRONMENT CANADA

BRIEF TO THE NOVA SCOTIA ROYAL COMMISSION ON FORESTRY

VOLUME II, SECTION 3

ENVIRONMENTAL PROTECTION SERVICE

Prepared by:

Robert C.H. Wilson
William R. Ernst
Gary Julien
Susan E. Hall

TABLE OF CONTENTS

SECTION 3: ENVIRONMENTAL PROTECTION SERVICE

Page

3.1 Objectives and Activities of EPS Relevant to Forestry 1
- 3.1.1 Environmental Assessment and Review Process 2
- 3.1.2 Fisheries Act 3
  - 3.1.2.1 Pollution Control Provisions 3
  - 3.1.2.2 Fish Habitat Protection 4
- 3.1.3 Public Consultation Policy 4
- 3.1.4 Interactions with Agriculture Canada 5
- 3.1.5 Federal Role in the Provincial Pesticide Permit Process 7

3.2 Ecological Aspects of Forestry Practices 8
- 3.2.1 Forest Resource 9
  - 3.2.1.1 Nature of the Resource 9
  - 3.2.2.2 Site Productivity 10
- 3.2.2 Poor Regeneration 10
- 3.2.3 Loss of Unique Ecological Sites 12
- 3.2.4 Impacts Following Clearcutting 17
  - 3.2.4.1 Alterations in Site Drainage 19
  - 3.2.4.2 Ground Disturbance and Erosion 21
  - 3.2.4.3 Nutrient Losses 22
- 3.2.5 Acidification of Soils and Receiving Waters 25
- 3.2.6 Acid Rain 27
- 3.2.7 Plantations 29
- 3.2.8 Economic and Administrative Aspects of IFM 34

3.3 Aquatic Effects of Pesticides 36
- 3.3.1 Pesticide Introduction to Aquatic Environments 37
  - 3.3.1.1 Direct Application to Surface Waters 37

TABLE OF CONTENTS (Continued)

Page

3.3.1.2 Mobilization in Ephemeral Stream Channels 37
3.3.1.3 Overland Flow 38
3.3.1.4 Leaching 38
3.3.1.5 Drift 38
3.3.1.6 Wind Erosion 40
3.3.2 Buffer Zones 41
3.3.3 Chlorophenoxy Herbicides 42
3.3.3.1 2,4,5-T, 2,4-D and Fish 43
3.3.3.2 2,4,5-T, 2,4-D and Aquatic Invertebrates 48
3.3.3.3 Secondary Effects 50
3.3.3.4 Residues 55
3.3.3.5 Polychlorinated dibenzo-para-dioxins (PCDDs) 60
3.3.4 Bacillus thuringiensis (B.t.) 68
3.3.4.1 Effects on Fish 68
3.3.4.2 Effects on Aquatic Invertebrates 69
3.3.4.3 Fate and Persistence of B.t. in the Aquatic Environment 70
3.3.5 Chemical Insecticides 72
3.3.5.1 Chemical Analysis of Environmental Samples 72
3.3.5.2 Fenitrothion 75
3.3.5.3 Aminocarb 90
3.4 Summary and Conclusions 102
3.5 References 113

3.1 OBJECTIVES AND ACTIVITIES OF EPS RELEVANT TO FORESTRY

The Environmental Protection Service (EPS) is responsible for ensuring that, to the extent that the federal government has influence or authority, human activities are conducted in a way that will achieve and maintain a state of the environment necessary for the health and well being of man, the health and diversity of ecosystems, and the sustained use of natural resources for social and economic benefit. This objective gives EPS a perspective of the forest in which a balance must be found between the long term health of the forest industry and the long term uses of the forest for other purposes.

Three of the activities of EPS are of particular relevance to the Commission:

(1) Advising the Canadian Forestry Service on matters pertaining to environmental quality. This activity is carried out as part of the federal Environmental Assessment and Review Process.

(2) Protecting fish from the harmful effects of chemicals used in forest protection and management. This activity is carried out under the pollution control provisions of the Canada Fisheries Act, and also through a consultation process with Agriculture Canada on the registration of new pesticides.

(3) Encouraging and supporting efforts by business, industry and labour to adopt environmentally responsible practices. This activity is carried out as part of the Public Consultation Policy of Environment Canada.

The authorities for these activities are outlined briefly below.

3.1.1 Environmental Assessment and Review Process

The federal Environmental Assessment and Review Process, established by Cabinet in 1973 and amended in 1977, embodies Canada's policy on environmental assessment as it relates to the activities of the federal government. Specifically, the projects which are subject to review under the Environmental Assessment and Review Process include:

- projects which are initiated by federal departments and agencies;
- projects for which federal funds are solicited and granted; and
- projects which involve federal lands or jurisdiction.

The federal Environmental Assessment and Review Process provides the opportunity for determining, in advance, potential environmental impacts of federal projects, programs and activities. Specifically, the process was designed to ensure that:

- environmental effects are considered early in the planning phases of new federal projects, programs and activities;
- an environmental assessment is implemented on all projects which may have an adverse effect on the environment before commitments or irrevocable decisions are made;
- projects considered to be environmentally significant are submitted to the Minister of the Environment for review; and
- the results of these assessments are used during the planning, decision-making and implementation phases of the project.

The federal assessment process is comprehensive and can involve up to three sequential stages of review: screening, preparation of an Initial Environmental Evaluation, and an Environmental Impact Statement. The first two stages (i.e., screening and Initial Environmental Evaluation) involve assessment by the federal agency initiating the project. If, on the basis of this review, the initiator concludes that effects are not significant, or can readily be mitigated, the project proceeds. However, if the effects are deemed significant, or are perceived to be significant from the public's point of view, the project is referred to the Minister of the Environment for a formal review by the federal Environmental Assessment and Review Office who administers the review on his behalf.

A new agreement for development of the forest industry was signed by Canada and Nova Scotia in August, 1982. Some forestry practices which will be initiated under this agreement (e.g., access road establishment, operation of heavy equipment, stand protection, weeding) have the potential for adverse impacts on the health and diversity of ecosystems. Because projects must be screened early in their development, it is important that environmental guidelines are available against which potential impacts can be judged and from which mitigating measures can be determined. The Nova Scotia Department of Lands and Forests carries out screening at the field level as part of its regular forest management program, with CFS providing a second, more general level of screening for projects which are funded under the Canada-Nova Scotia Forest Resource Development Agreement. Guidelines for forest road construction have been accepted, but there is a need for further federal-provincial cooperation in the development of guidelines for other aspects of the forestry cycle.

3.1.2 Fisheries Act

The Fisheries Act (R.S.C. 1970 c.F-14) is concerned with the protection of seacoast and inland fisheries. The Department of Fisheries and Oceans and Environment Canada both have major roles to play in enforcing this legislation. While the Minister of Fisheries and Oceans is responsible to Parliament for the Fisheries Act, DOE administers the pollution control provisions (Sections 33 to 33.4) under administrative arrangements with the Department of Fisheries and Oceans.

3.1.2.1 Sections 33 to 33.4 - Pollution Control Provisions. Section 33 prohibits the deposit of substances which are deleterious to fish, fish habitat or man's use of fish, into waters frequented by fish.

The general provisions on pollution control contained in Section 33(2) are used by EPS as a basis for its program to review and control the effects of pesticide applications, described later in this brief.

Section 33 also provides authority to make regulations prescribing deleterious substances and authorizes the deposit of a specified amount of deleterious substances [Section 33(4)]. EPS has used this section to develop regulations and guidelines for the control of discharges from specific industries. An interdepartmental task force was convened by EPS to evaluate the feasibility and practicality of implementing a regulation to control aerial forest spray operations against the spruce budworm. This group reported in 1981 that it would not be practical, desirable, appropriate nor necessary to develop such a regulation.

In addition to the above, Sections 33 to 33.4 contain authority to recover costs and expenses for the cleanup of spills of substances such as pesticide [Section 33(10)], to direct spill cleanup (Section 33.2), and to enforce the general provisions on pollution prevention (Section 33.1).

3.1.2.2 Section 31 - Fish Habitat Protection. The amendments to the Fisheries Act (1976-77 Statutes of Canada, Ch. 35) provided new general provisions for the protection of fish habitat (Section 31). Other provisions (Sections 20, 28 and 30) already dealt with specific habitat problems. These sections are used by the Department of Fisheries and Oceans as the basis for its program to review and control physical disruptions to fish habitat caused by forestry operations. The problems of stream siltation and flow alteration have been described in the presentation of the Department of Fisheries and Oceans to the Commission.

3.1.3 Public Consultation Policy

The Minister of the Environment recognizes the importance of effective communication with the public in determining departmental policies, programs and regulations and in making scientific information available as the basis for informed decisions outside the department. Environment Canada's policy for public consultation and information availability has these components:

- A framework for public consultation provides for the public and officials to discuss matters of mutual interest regularly, including programs and policies at headquarters and in the regions.
- A specific regulation-making component assures the public of an opportunity to comment on all significant regulations proposed by the department.
- For the public to provide informed comment on departmental activities, and for informed decisions about the preservation and enhancement of environmental quality to be made outside the department, an information availability component permits access to most departmental data and published materials.
- The contribution to transportation expenses section of the policy provides financial assistance for public interest groups and professional associations to attend designated departmental meetings at headquarters and in the regions.

Information about the effects of forestry practices on environmental quality has been provided to industry and to public interest groups to assist in the preparation of guidelines for environmental protection and to promote informed discussion of issues such as forest spraying.

3.1.4 Interactions with Agriculture Canada

The responsibility for the federal registration of pesticides under the Pest Control Products Act lies with Agriculture Canada. Each pesticide product which receives a registration number and use pattern from Agriculture Canada is subjected to an evaluation of its potential effects on human health and the environment.

During this process, toxicological and environmental behaviour data which have been developed by the prospective registrant are reviewed through a formal consultative mechanism by technical experts of Environment Canada, Health and Welfare Canada, Fisheries and Oceans Canada and Agriculture Canada. It is through this review process that Environment Canada is most able to affect the manner in which pesticides are used. From an environmental standpoint, as part of each pesticide registration, data must be provided for:

- the effect the chemical has on the target organism;
- the toxicological effect the chemical has on selected laboratory organisms;
- the toxicological effect the chemical has on endemic or indicator species;
- the major pathways and products of the chemicals' metabolism in selected animal species;
- the behaviour of the chemical in different components of natural and artificial environments, as well as the residue concentration which may be expected with different use patterns;
- the total formulation composition and its physical and chemical properties; and
- the residues which may be expected on various crop species.

Based on the evaluation of the data which has been submitted, a recommendation is made to Agriculture Canada that:

- the chemical be provided full registration status; or
- a request be made for additional studies; or
- in the case of demonstrated unacceptable impacts, a complete denial of registration or modified registration.

All of the presently used forestry pesticides have been subjected to this review process.

3.1.5 Federal Role in the Provincial Pesticide Permit Process

The granting of permits for individual pesticide applications is a provincial responsibility. In Nova Scotia, as in the other Maritime Provinces, all provincial pesticide permit requests are reviewed by a federal environmental committee known as the Atlantic Region Pesticides Advisory Committee (ARPAC). This committee, which is made up of representatives of Environment Canada and Fisheries and Oceans Canada, makes recommendations for mitigative permit stipulations to the provincial regulatory authorities on a case by case basis.

These recommendations are primarily concerned with precautions which must be taken to:

- reduce the drift of spray formulations to non-target areas (i.e., buffer zones, meteorological restrictions);
- identify environmentally sensitive areas such as ecological reserves and fish spawning sites; and
- ensure proper disposal and handling techniques.

This referral system also serves to notify the federal agencies involved of upcoming pesticide programs within the region. Using such information, those agencies which have an interest are better able to arrange and coordinate monitoring or research activities. Little information is available about the application of pesticides by a non-Crown landowner to his own property. Provincial permits are not required for such applications. A mechanism is, however, being developed to ensure that ARPAC reviews pesticide treatment plans from private landowners if they are to be funded under the Canada-Nova Scotia Agreement on Forestry.

3.2 ECOLOGICAL ASPECTS OF FORESTRY PRACTICE

The purpose of this portion of the brief is to present some of the environmental implications of present day forestry programs. The diverse set of site conditions found in Nova Scotia, as well as varied field practices, make environmental assessment(s) very complex. These variations have contributed to disparities in the literature on forestry-related impacts, which have ranged from negligible to severe. Studies on environmental impacts of forestry practices have generally been done in the United States where impacts on site characteristics and the fishery may be less due to initially more favourable conditions and the nature of non-forestry resources. The literature on the impact of site treatments (such as mechanical site preparation or herbicide application) used in intensive forest management is small relative to the literature on harvesting practices and road construction. These factors combine to make a description of forestry-related impacts difficult in the context of Nova Scotia.

Environment Canada supports the widespread adoption of intensive forest management (IFM) as a means of promoting good practice. Systems such as regeneration cutting and patch cutting which are a part of IFM have largely been neglected in Nova Scotia in the past. Many of the problems associated with IFM in this section of the brief are the result of a clearcut or clearcut-and-plant philosophy which has grown up with our present industry.

It is important to emphasize that any practice, when abused, can lower the quality of a forest ecosystem. Some practices, singled out below as causes of environmental degradation, are practices which benefit all users of the forest if properly applied. Our approach below has been to point out the potential for damage if forestry programs are poorly applied. We hope that the Comissioners will appreciate that this bias towards environmental protection still reflects a belief that sound forestry practices are also sound environmental practices.

3.2.1 Forest Resource

3.2.1.1 Nature of the Resource

Nova Scotia's 4.3 million hectares of forested land are presently covered by a mixture of coniferous (53%), deciduous (18%) and mixed woods (30%) comprising the eastern-most extension of the Acadian Forest Region. The characteristic climax forest is transitional between the coniferous forest to the north and the deciduous forest to the south, but is ecologically distinct with several more or less endemic species, including yellow birch, eastern hemlock, white pine and red spruce (Canadian Committee for the International Biological Program, 1974).

The 300 year history of forest exploitation, however, has had a profound effect on Nova Scotia's forests, in many instances obscuring that attributable to climate and geology. Widespread changes in species composition have occurred and old growth stands of hemlock, red spruce and northern hardwoods are now rare. A significant portion of the present Nova Scotia forest consists of stands of even aged softwoods (mainly balsam fir and black spruce) or shade intolerant hardwoods of low commercial value (white birch, pin cherry and alders). Extensive areas of heath-dominated barrens have occupied formerly forested land primarily due to wildfires and fires associated with logging. Past logging practices such as high-grading for sawlogs (selective removal of the best trees and species, leaving inferior trees and less desirable species) and poor regeneration following fire and clearcutting are thought to have contributed to these changes, resulting in a degraded resource base.

3.2.2.2 Site Productivity

Site productivity, reflecting site quality, is an important factor determining the magnitude of impact resulting from forestry-related disturbance. According to ecological theory, "poorer" sites have less recuperative capacity and are not expected to recover completely when severely disturbed, such as by fire or certain types of forest harvesting. Reductions in site productivity may be caused by soil compaction, increased erosion, significant nutrient losses, or alterations in site drainage, all of which are discussed later.

None of Nova Scotia's forested land is considered to be of the highest quality for the production of commercial forests (for example, Class 1 or 2 in the Canada Land Inventory). The inherently low to moderate productivity of much of Nova Scotia's forested land is related to a short growing season and frequently encountered conditions such as shallow or nutrient-poor acidic soils or locally impeded site drainage (Goldsmith, 1980). For example, the prevalence of slow-weathering granite and igneous formations result in nutrient-poor, acidic soils throughout much of southwestern Nova Scotia.

Site conditions in Nova Scotia both limit potential productivity and increase the severity of potential environmental impacts, relative to better quality sites elsewhere in southern Canada and the United States. The moderate to low capacity of Nova Scotia's forested land to produce commercially usable trees should be considered in the development of forest management programs. Costs (both ecologically and economically) of current IFM policies will be increasingly important factors on poor quality sites.

3.2.2 Poor Regeneration

Clearcutting of the boreal forest type found in Cape Breton generally results in adequate, if overly dense regeneration. On the other hand, clearcutting a mature mixed or hardwood forest is not expected to result in regeneration of that forest type. Regeneration following cutting of these sites has frequently consisted of commercially undesirable species (for example, alders, pin cherry and wire birch). Better sites have frequently regenerated to overstocked stands and to balsam fir, which has proven vulnerable to insect damage. These problems with forest regeneration are not unique to Nova Scotia, as similar problems occur throughout Canada.

Such problems, however, may be occurring at an increased rate because forestry operations are being conducted on poorer quality sites (such as poorly drained black spruce sites, or steep slopes). Significant disturbance (clearcutting or fire) on sites of marginal capacity can be expected to result in slow and incomplete regrowth and exacerbation of impacts such as erosion and nutrient losses. Mechanization of harvesting during the last decades may also have contributed to present problems with regeneration because it facilitated larger clearcuts, more complete tree removal and destruction of the understory, creating an environment unsuitable for the survival of desired shade-tolerant species (Wall, 1975). Clearcutting of mixed softwood/hardwood stands has encouraged regeneration by low value, shade intolerant hardwoods and ericaceous (heath and scrub) vegetation on poor quality sites. Differences between the 1958 and 1965-1971 forest inventories for Nova Scotia indicate that while hardwood species of low economic value such as red maple and white birch (which often comprise natural regeneration following clearcutting) have increased significantly, valuable species such as sugar maple, yellow birch and white ash have decreased (Henry, 1981; Goldsmith, 1980). Clearcutting of mixed fir/spruce stands has also resulted in extensive balsam fir regeneration, undesirable because of the vulnerability of such stands to attack by the budworm.

Selective cutting practices, often recommended as an alternative to clearcutting, have been carried out so incompletely in some parts of

Nova Scotia that the result resembles highgrading. Such practices, often for the purpose of obtaining sawlogs, have contributed to the overall decline in the quantity and composition of the forest.

Without widespread adoption of cutting practices modified to preserve or promote desirable regeneration, the degradation of forest quality will continue on a significant proportion of the cutovers in Nova Scotia. Accompanying the decline in forest quality will be increased erosion, stream siltation, declines in site productivity, and other effects which are the subject of discussion below.

3.2.3 Loss of Unique Ecological Sites

Nova Scotia's forests were once largely comprised of a mixture of coniferous and hardwood elements (as outlined above). The few remaining stands of old growth climax forest are attractive logging sites and are endangered by forestry operations and other disturbance because of their unprotected status. Because these remnants comprise Nova Scotia's most characteristic and diverse flora and fauna, relatively large numbers of the sites in Nova Scotia recommended as ecological reserves by the International Biological Program (Table 3.1; Figure 1) are forested (Canadian Committee for the I.B.P., 1974). In 1974, a directive was sent out by the Deputy Minister of Lands and Forests to resource managers informing them of the location of the sites in Nova Scotia recommended as nature preserves by the IBP. Since that time, the protection of these sites has been subject to the discretion of area managers; no formal, publicly recognized protection has been accorded them.

Apart from the I.B.P. sites, other areas of Nova Scotia are also ecologically sensitive. Old growth forests, wet woodland and other forested areas contain many associations of species whose distribution is quite limited in Nova Scotia or in Canada (Isnor, 1981). These species are vulnerable to clearcutting and other silvicultural treatments such as

TABLE 3.1

I.B.P. - C.T. SITES RECOMMENDED AS ECOLOGICAL RESERVES

Map #	Site Name	Ecosystem	Approximate Acreage
1	Cape d'Or	Arctic-Alpine Habitat	96
2	Shulie River	Red Spruce Forest	77
3	Chignecto	Red Pine Forest	77
4	John Lusby Nat. Wldf. Area	Salt Marsh	1,613
5	Fenwick	Deciduous Forest	182
6	Black River Road	Jack Pine Forest	57
7	Moose River	Red Spruce Forest	800
8	Economy River	Old-Growth Red Spruce Forest	192
9	Kemptown	River Intervale: Rare Plants	1
10	Glencoe	River Intervale: Rare Plants	2
11	Clydesdale	Deciduous Forest	192
12	Black River	Alkaline Bog	750
13	Piper Glen	Mixed Forest	67
14	Lake O'Law	Old-Growth Deciduous and Coniferous Forests	86
15	Second Fork Brook	Old-Growth Deciduous Forest	144
16	Petit-Etang	Eutrophic Marsh	230
17	French Mountain Lake	Lake and Bogs	134
18	French Mountain Bog	Sphagnum Bog	38
19	Grande Anse River	Old-Growth Deciduous Forest	4,000
20	Sunday Lake	Boreal Forest, Barrens and Bogs	14,880
21	North Aspy River	Old-Growth Deciduous Forest	634
22	French River	Old-Growth Mixed Forest	221
23	Oregon	Old-Growth Hemlock Forest	48
24	Bird Islands	Bird Nesting Site	154
25	Marion Bridge	Deciduous Forest	134
26	Point Michaud	Beach and Sand Dunes	393
27	Melrose	Old-Growth Hemlock Forest	65
28	Bickerton Island	Bird Nesting Site	30
29	Tobacco Island	Bird Nesting Site	25
30	Little White Island	Bird Nesting Site	19

.../2

TABLE 3.1 (Continued)

Map #	Site Name	Ecosystem	Approximate Acreage
31	Abraham Lake	Red Spruce Forest	125
32	Brokenback Island	Bird Nesting Site	14
33	Long Island	Bird Nesting Site	10
34	Pumpkin Island	Bird Nesting Site	16
35	Horse Island	Coastal Island	15
36	Conrad Beach	Barrier Sand Dunes	86
37	Kidston Lake	Barrens; Rare Plants	134
38	Bear Cove	Sphagnum Bog	19
39	Duncan's Cove	Coastal Barrens	547
40	West Dover	Coastal Barrens and Bogs	450
41	Hollahan Lake	Jack Pine Forest	10
42	Burnaby Lake	Red Spruce Forest	96
43	Shelburne River	Old-Growth Hemlock Forest	154
44	Sixth Lake	Hemlock-Red Spruce Forest	200
45	Broad River	Red Spruce Forest	125
46	Carter's Beach	Sand Dunes	96
47	Silvery Lake	Old-Growth Hemlock Forest	20
48	Shelburne Barrens	Fire Barrens	13,968
49	Sandhills Beach	Sand Dunes and Salt Marsh	50
50	Quinan Lake	Old-Growth Mixed Forest	1,325
51	Moses Lake	Old-Growth Deciduous Forest	29
52	Spinney's Heath	Sphagnum Bog	691
53	Chebogue Lake	Tidal Lake	288
54	Hectanooga	Eastern White Cedar Swamp	154
55	Cape Saint Mary	Sand Dunes and Salt Marsh	325
56	Placid Lake	Lake and Old-Growth Hemlock Forest	432
57	Belliveau Lake	Lake and Rare Plants	740
58	Grosses Coques	Salt Marsh	125
59	Brier Island	Sedge and Sphagnum Bogs	340
60	Ventral Bog	Sphagnum Bog	240
61	Birch Lake	Old-Growth White Pine Forest	400
62	Sporting Lake	Old-Growth Hemlock-Pine Forest	80
63	Big Dam Lake	Old-Growth Hemlock Forest	375
64	Kentville Ravine	Old-Growth Hemlock Forest	96

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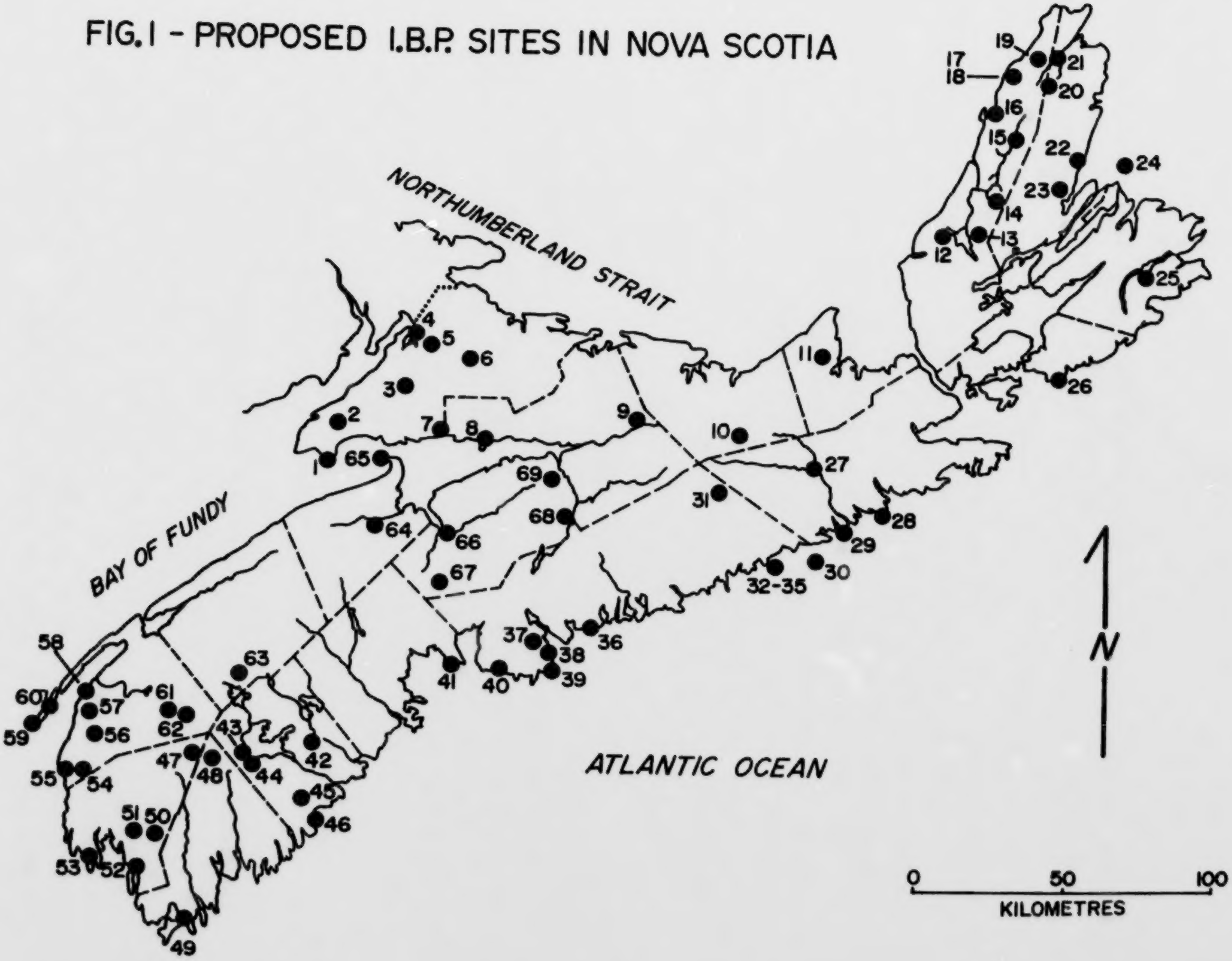
TABLE 3.1 (Continued)

Map #	Site Name	Ecosystem	Approximate Acreage
65	Cape Split	Deciduous Forest and Arctic-Alpine Habitat	1,100
66	Saint Croix River	Mixed Forest and Rare Plants	300
67	Shady Brook	Red Spruce-Hemlock Forest	220
68	Shubenacadie	Rare Plants	35
69	South Maitland	Gypsum Cave and River Intervale	365
APPROXIMATE TOTAL ACREAGE			49,136

FIG. I - PROPOSED I.B.P. SITES IN NOVA SCOTIA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plantation establishment and site drainage. Non-forested areas are also vulnerable to associated practices such as road construction and habitat alteration.

Immediate priority should be given to the formal preservation of the sites identified by the I.B.P. program in 1974. The recently proclaimed "Special Places Protection Act" of Nova Scotia might provide a vehicle for such designation. Although 35 of the 69 sites identified by the I.B.P. were forested in 1974, making all of the I.B.P. sites commercially unavailable would remove the equivalent of less than half of one percent of the province's forested land. Non-forested sites may still be vulnerable to the effects of access road construction (and other impacts). These sites should be protected prior to further implementation of forestry programs.

3.2.4 Impacts Following Clearcutting

The literature on the relatively short term impacts which may follow clearcutting is extensive. The nature, size, or occurrence of an adverse impact is highly site specific and, unfortunately, published studies on Nova Scotian sites are very few. As well, operator technique has a great deal to do with whether adverse impacts occur, particularly on better quality sites. While the impacts outlined below are described in the scientific literature, the extent to which they are found in Nova Scotia can be quantified only through personal experience.

Most of the relatively short term (less than 10 years) ecological effects of clearcutting are related to the removal of the stand, destruction of understory vegetation, ground disturbance from harvesting machinery, skid trails, and the construction of access roads and landings. Impacts may include: alterations in site hydrology, including changes in site runoff and subsequently the magnitude and timing of peak flows, changes in drainage patterns which may convert poorly drained sites to wet sites, ground disturbance, erosion, and compaction, subsequent stream siltation, and nutrient losses from leaching and erosion. The magnitude and duration of these impacts are site specific and highly variable, being a function of site conditions: soil depth, fertility, erodability, slope, the extent, nature, and rate of natural regeneration, the extent of ground disturbance, and the size of the clearcut and operator technique.

Clearcutting is usually followed by rapid regeneration of colonizing species (such as pin-cherry, alders, stump-sprouting hardwoods and raspberry). Although commercially undesirable, these species are of great importance ecologically because they: regenerate quickly providing ground cover which inhibits erosion; promote re-establishment of evapo-transpiration processes and associated flow regulation in streams; restore site productivity through annual litter production (which decomposes slowly to release nutrients) and the nitrogen-fixing activity associated with some species such as alders; and provide browse, cover, and nesting habitat for wildlife. Small clearcuts may have a positive impact on wildlife because of the production of quantities of browse adjacent to mature forests.

Impacts related to nutrient losses and erosion are usually not significant after about five years, on good quality sites (moderate slopes, medium textured soils, moderate to high organic content) where environmental guidelines and approved practices were followed and natural successional growth has recurred (Freedman, 1982). In Nova Scotia, however, current demand and wood shortages are resulting in increased harvesting on poor quality sites (such as poorly drained or steep-sloped areas), where impacts are expected to be more significant or longer lasting.

Implementation of environmental guidelines has met with limited success. In fact, there has been active and vocal opposition by some representatives of the forest industry to regulation of the industry under the Nova Scotia Forest Improvement Act.

3.2.4.1 Alterations in Site Drainage

During the growing season, stream flow and site drainage are regulated to a large degree by the uptake of soil-water by plants and its release from leaves and stems (transpiration). Transpiration, along with interception by the canopy and evaporative water losses, markedly reduce overall stream water output and lessen peak flows following storms. Stream siltation is controlled because particulate matter losses, through erosion and stream transport, strongly correlate with flow rate or peak flows (Likens, _et al_, 1978; Bormann _et al_., 1974).

Clearcutting results in the loss of the moderating effects of the forest canopy: transpiration, interception by the canopy, and shading. Peak flows are subsequently increased and soils become wetter. The magnitude of the increase in peak flow has been found to be highly variable, but generally proportional to the size of the clearcut(s) relative to the watershed area, and the extent and severity of ground disturbance. With ground disturbance and compaction, the infiltration capacity of the soil is reduced (N.C.A.S.I., 1981) and water flows more rapidly from the site and into watercourses. Highly compacted surfaces such as roads and skid trails may also tend to channelize the runoff so it is more rapidly routed to streams.

Increased runoff is of concern because it enhances site erosion (especially on disturbed surfaces). The larger stream flows may also erode stream banks causing bank instability and additional stream siltation. Bank and channel erosion can be an important source of sediment to estuaries and downstream ponds and lakes. The scour and fill of the stream-bed may temporarily or permanently reduce stream biota and available spawning habitat for salmonids. Culverts intended to handle pre-cut stream flow may now be undersized, resulting in culvert and road washouts and additional erosion and stream siltation.

Flash runoff from cutover sites may result in reduced stream flow during dry periods. Low flows are of concern due to impeded fish passage and possibly higher water temperatures.

Limiting the proportion of the total area clearcut within a watershed and allowing rapid revegetation of the cutovers will reduce the magnitude of change in stream flows. Soil compaction, however, is difficult to remedy and can have long term deleterious effects on site productivity. The extent and severity of ground disturbance can be reduced through: designing landings and roads to occupy the least area; designing extraction roads to minimum standards for speed and visibility; following environmental guidelines and codes of good practice for access road construction; and the judicious use of harvesting machinery, especially with regard to local site conditions (such as slope, drainage and soil wetness).

Poorly drained sites may be transformed to wet sites following clearcutting. Causes are the loss of transpiration and the reduced infiltration capacity of the soil resulting from compaction. In such areas, often former black spruce stands, regeneration will not occur because of excessive pools of standing water following precipitation. Restoring these areas to forest production involves extensive and expensive site preparation, drainage, and planting. As these areas may be of marginal commercial value initially, it may take several cycles to recoup the total costs of harvesting and restoration. Clearcutting of these areas should not, therefore, occur unless modified harvesting methods will reduce post-cut drainage problems.

An additional consideration in any decision to harvest wet woodland areas is the possible presence of rare and endangered plants and animals (Isnor, 1981).

3.2.4.2 Ground Disturbance and Erosion

Skidder logging has the potential to cause significant ground disturbance and compaction, resulting in site degradation and reduced productivity. Local site conditions and operator technique will, however, govern whether the actual impact will be negligible or severe. Local site conditions of importance in determining the severity of ground disturbance include soil wetness and texture, site drainage, soil erodability, the slope of the land, and the operating season (for example, whether the ground is frozen). Unfortunately, published studies on the extent of the problems caused by skidder logging in Nova Scotia are lacking, although a survey of Fisheries Officers that we conducted in 1979 identified logging operations as an important cause of stream siltation in forested areas.

In Newfoundland, however, skidder logging operations have been shown to result in deep mineral soil exposure on about 10% of the cutover area (Case and Donnelly, 1979). In Nova Scotia, with about 40,000 ha cut annually, similar practices would affect 4,000 ha per year of productive forest land and possibly remove such land from future commercial production. Compaction affected 30% of the unbulldozed portions of the cutovers studied in Newfoundland (Case and Donnelly, 1979). Softwood regeneration in these areas tends to remain sparce and suppressed for much of the rotation period.

Ground disturbance is also of concern because of erosion and siltation of streams. Stream biota, especially salmonids and aquatic insects (a major food source for the fish), may be adversely affected both by the short term increased turbidity and the longer term movement of coarser sediment fractions along the channel bed. A study at several sites in Nova Scotia and New Brunswick demonstrated that present forest harvesting activities are unlikely to affect the standing crop of salmonids except in locations where poor road-stream crossings are built (Englert *et al.*, 1982). Effects on spawning were not examined, but it is expected that sediment would clog the inter-gravel spaces, reducing oxygen exchange and eliminating clean spawning habitat for salmonids. It may take a decade or more, in some cases, for natural forces to clear a stream of sediment.

Ground disturbance also accelerates nutrient losses by leaching and sediment transport, as discussed in the following section.

Ground disturbance and erosion are therefore of concern because of potential effects on site productivity and on stream biota. Ground disturbance can be reduced by following available environmental guidelines for access road construction and minimizing the cutover area taken up by roads, landings and skid trails. Limiting logging to winter periods or dry periods, and avoiding poorly drained areas will also reduce ground disturbance. Erosion can be minimized by allowing or actively encouraging rapid revegetation of the site by colonizing species. Residual impacts, however, may still be significant even when environmentally acceptable practices are followed because of the preponderance of relatively poor quality sites now being logged. In addition, the wet Maritime climate of Nova Scotia may limit the success or implementation of remedial practices.

The use of alternative harvesting methods, such as shelterwood and various selective cutting techniques, should greatly reduce compaction and ground disturbance on cutovers at the cost of increasing the requirement for roads. Access roads, however, accompany all forestry operations regardless of the harvesting method, and will remain the most significant source of erosion and sediment in the absence of appropriate mitigation measures.

3.2.4.3 Nutrient Losses

Forests store nutrients in the standing vegetation and leaf litter layers, and cycle nutrients between plant and soil compartments (Likens et al., 1978). Nutrient losses from a forested site are minimal, and stream nutrient levels consequently low.

Clearcutting results in an accelerated loss of nutrients because of: increased runoff and nutrient leaching due to the loss of evapo-transpiration; the loss of nutrients tied up in the harvested stand; the loss of biotic conservation of nutrients through uptake by plants; the loss of nutrients bound to eroded soil particles due to ground disturbance; and accelerated decomposition of litter and soil organic matter (Likens et al., 1978; McColl and Grigal, 1979). Decomposition on cutovers is accelerated by the increased soil temperature and soil wetness, the greater amount of organic material on site from logging debris and the subsequent increased populations and activity of microbes (McColl and Grigal, 1979). As the nutrients resulting from this rapid decomposition are lost through leaching or particulate runoff, future site productivity is of concern. It has been suggested (Likens, et al, 1978) that rotation times should be long enough for the ecosystem to regain, through natural processes, nutrients and organic matter equivalent to those lost through the above. Studies in the U.S. White Mountain Region suggest that about 65 years is required for organic matter in the forest floor to rebuild to pre-cutting levels. The loss of soil organic matter over time is a common concern in agriculture, and can only partially be compensated for by the addition of fertilizer.

Actual nutrient losses following clearcutting will vary greatly depending on site conditions (such as forest species composition, time of cutting, rate and type of regeneration, precipitation and temperature patterns, and the extent and severity of ground disturbance and associated erosion). The magnitude of nutrient loss, relative to available nutrient reserves, is expected to be small on better quality sites (Freedman, 1982), unless ground disturbance is extensive (Hornbeck and Urser, 1979). Rapidly growing vegetation on cutovers will quickly curtail nutrient losses by stabilizing the site and reducing erosion, and through uptake of nutrients (McColl and Grigal, 1979). Nutrient losses may be of significance under several circumstances: on poor quality sites such as those with thin, nutrient poor, or acidic soils; if slash deposition is large and regeneration subsequently inhibited; if soil and litter layers are extensively disturbed or compacted, resulting in erosion and the loss of nutrients bound to soil particles; if whole tree harvesting is practiced, especially on relatively infertile sites; and if short rotations are utilized. The loss of nutrients with whole tree harvesting is disproportionally large because the additional branches and tops removed from the site are relatively nutrient-rich (Freedman, 1982).

The significance of nutrient loss in terms of future site productivity is largely undocumented, but presumably similar to agricultural land in the eventual need for imported nutrients to maintain production. Documented losses in site productivity following clearcutting have mostly been associated with deterioration in physical soil properties, such as increased compaction or drainage alterations. Where severe deterioration in site physical and biological properties has occured, fertilizer applications (considered an integral part of IFM, but not yet practiced to any extent in Nova Scotia) are not expected to completely restore productivity (Ballard, 1979).

The results of studies on the efficacy of fertilizers to increase forest production have varied greatly. This is probably due to the dominance of site factors such as drainage and compaction (Ballard, 1979) and natural variation in growth and survivorship (Salonius, 1981), which can obscure the possible effect of fertilizer applications. An increased incidence of disease and insect damage has also been correlated with fertilizer application, although the basis of this is not understood (Ballard, 1979). Application of water soluble fertilizers is expected to contribute to nutrient enrichment of receiving waters, although this may actually be a benefit in Nova Scotia.

Intensive mechanical site preparation, used to control broadleaf competition on cutovers prior to plantation establishment, is of additional concern because of the resulting extensive ground disturbance and compaction and disruption of nutrient cycling.

The leaching of soluble nutrients from harvested watersheds does result in higher nutrient concentrations in streams draining clearcuts. The short-term increase in nutrient concentration is not, however, expected to significantly degrade water quality in most of Nova Scotia and may result in a short-term increase in aquatic productivity.

In summary, although there are data substantiating nutrient losses following clearcutting, there is little evidence linking these losses to reductions in site productivity. Intensive harvesting practices do strongly modify site properties known to be important in determining productivity (Ballard, 1979).

The cumulative environmental effects of all the site treatments used in IFM, including mechanical and herbicide site treatments and prescribed burns, have not been assessed in terms of possible site nutrient depletion. Additional studies are needed, and the environmental effects of a proportion of future forestry projects should be monitored in order to provide appropriate feedback to resource managers and woods operators.

3.2.5 Acidification of Soils and Receiving Water

Acidification of surface waters and soils is thought to be due mainly to the deposition of acids carried in the atmosphere for large distances from their source. There are, however, several potentially important sources of acidification that are related to forest composition, harvesting and other forest management activities. The importance of these alternative sources to Nova Scotians has not yet been assessed.

Soils of the conifer-dominated boreal forest are naturally acidic due to accumulations of slowly decomposing, acidic leaf litter. Hardwood and mixed stands do not tend to accumulate such large amounts of acidic organic material, in part because their annual loss of leaves opens the canopy, providing greater light penetration, higher soil temperature and thus more rapid and complete decomposition of leaf litter. In addition, the throughfall of rainwater is less acid in hardwood stands than in conifer stands due to differences in the ionic content of material leached from the leaves by water droplets (Braekke, 1976; Richter and Granat, 1978).

Rosenqvist (1978) has pointed out that the acidic, humus-rich soils of the conifer forest will tend to buffer incoming precipitation to an acidic pH regardless of the original pH of the rainfall. It is thought that this effect would be enhanced if runoff is rapid, flowing through the duff and humus without contacting the underlying, more basic mineral soil. This would tend to occur after a heavy rainfall, after clearcutting or other major deforestation, and during the spring melt period when the underlying soil is still frozen. We have indications that this process is occurring in at least one watershed in Cape Breton.

After a stand is clearcut, more rapid decomposition of any accumulated organic material occurs due to increased light penetration, soil temperature and microbial activity. Decomposition results in the production of ammonium, which undergoes a two-step oxidation to nitrate plus hydrogen ions in a microbially mediated process called nitrification. In this conversion, one equivalent of ammonium is broken down into one equivalent of nitrate and four equivalents of hydrogen ion (Henderson et al., 1980). In acid soils in which ammonium is oxidized and in which the pH is either initially below about 5.5 or falls below that value as a result of nitrification, appreciable losses of nitrogen occur through volatilization as nitric oxide (Alexander, 1961). This loss means that denitrification, a microbial process which balances nitrification in more neutral and basic soils by consuming hydrogen ions, does not occur to the same extent as nitrification and there is a net excess of hydrogen ions. This production of water soluble acid is thought to account for the frequently reduced pH of streams draining clearcuts and it has been suggested (Reuss, 1976) that the resulting contribution to acidification may be of the same order of magnitude as the direct input of hydrogen ion from acidic deposition.

Practices which alter the species composition of the forest may, therefore, result in soil and water acidification in the long term. Although stand conversion to softwoods would have to be carried out on a much larger scale than is presently planned for a major impact to occur, localized impacts on small watersheds are still possible.

The characteristics of the mixed and hardwood forest ecosystem work against most of the above processes and may also reduce the impact of acid rain. A significant hardwood component (perhaps 10-15% stems) should be actively maintained in both the naturally regenerated forest and within plantations, particularly in southwestern Nova Scotia, where the surface waters are most susceptible to the addition of acid (Clair et al, 1982).

Soil disturbance, especially from access road construction, may also result in acidic runoff in areas where pyritic rock formations are near the surface. Gravelling roads with materials derived from these rocks enhances the rate of acid production due to the greater surface area exposed once the rock has been crushed. Roads in such areas should not contain pyritic fill and should be constructed to minimum standards for speed and visibility, thus reducing deep soil disturbance and should immediately be stabilized and seeded.

3.2.6 Acid Rain

Recent research by the Canadian Forestry Service and others points to effects on tree seedlings and forest growth due to the phenomenon known as acid rain. Acid rain also affects many other parts of the forest ecosystem from terrestrial insects to fish.

In Nova Scotia, there is a considerable deposition of acidifying substances, principally sulphate, from the atmosphere. The rate of deposition by rain and snow is about 30 kilograms sulphate per hectare per year (kg ha^{-1} y^{-1}), which is well in excess of the target loadings of 20 and 10 kg ha^{-1} y^{-1} that have been proposed for moderately and very sensitive ecosystems, respectively, by the Impact Assessment Working Group of the United States-Canada Memorandum of Intent on Transboundary Pollution. The wet deposition of 30 kg ha^{-1} y^{-1} is estimated to be 75 to 80% of the total atmospheric deposition; the other 20 to 25% is by dry processes such as diffusion (Shaw, 1982).

There are considerable month-to-month and year-to-year fluctuations in the deposition, and no trend has been discernable since continuous monitoring began in 1975. However, the present precipitation has a hydrogen ion content (acidity) 20 times that in precipitation collected by the only available historic study in the 1950's.

Meteorological analyses suggest that 75 to 80% of the acid deposition in Nova Scotia comes from outside the province, mainly from the eastern and central United States and central Canada. The reason for this large import of sulphur is due to a frequent southwesterly flow of air which has passed over strong source regions. This air is also moisture-laden, a condition which is conducive to the rapid removal of sulphates by precipitation (Wiltshire, 1979).

The 20 to 25% of the deposition accounted for by Nova Scotian sources is most strongly felt within 25 to 50 kilometres of strong regional source areas such as Halifax. Within this distance, it is estimated by monitoring and computer modelling that deposition from local sources can be as great or greater than that caused by long range transport from other parts of Canada and the United States. The model estimates that about 40% of local emissions is deposited, mostly by precipitation, within 50 km of the source; the other 60% joins the large-scale atmospheric flux of acidic materials (Shaw, 1982).

Even if all of the sulphur could be removed from emission sources located in Nova Scotia (a technical impossibility), depositions within the province would still be above the target just mentioned. There are thus two reasons for reducing sulphur emissions within Nova Scotia, both founded on protecting the integrity of forest ecosystems:

- to meaningfully reduce depositions close to source areas; and
- to demonstrate a willingness on the part of Nova Scotians to cooperate in a national and international strategy to abate acid rain.

Control of sources both inside and outside Nova Scotia is needed to reduce deposition of sulphate to an acceptable level.

3.2.7 Plantations

Clearcutting, as presently practiced, results in commercially undesirable regeneration on a significant portion of the cutovers in Nova Scotia (as discussed previously). As remedial silvicultural measures in the past have been minimal, there is now a large backlog of forested land that is considered commercially unproductive.

In order to overcome future softwood supply shortages, it is proposed to establish coniferous plantations annually on about 11,200 ha (28,000 acres) or 1/3 of the annual cutover area. These programs will be assisted by federal and provincial funding during the next five years. This amounts to about 56,000 ha, about 3% of the better quality forested land (Class 3 and 4) or 1% of the total forested land. Primarily spruce and pine are to be planted in order to reduce the balsam fir component of the forest. Balsam fir has frequently comprised natural softwood regeneration following disturbance of the original forest, and has proven very susceptible to insect epidemics.

Intensive forest management may involve some or all of: site preparation, both mechanically and chemically (scarification, prescribed burning, herbicide treatment, etc.), herbicide suppression of competing hardwoods, reforestation with nursery-grown conifers, increased use of chemicals in order to control disease and insect problems, and increasing mechanization of all aspects of forestry operations.

The Rogers Commission in B.C. concluded that a lack of economic evaluation in the implementation of intensive forest management programs was an impediment to their success. In B.C., treatments were being applied to sites without a rigourous consideration of whether better alternative treatments or more appropriate sites for that treatment were available. The absence of a formal economic evaluation in Nova Scotia means that reforestation efforts will not necessarily be applied to those sites where the most economic benefit and least resource conflicts can be expected. The cost of plantations and the accompanying trade-offs in terms of reduced capacity for other forest uses suggest that reforestation be carried out only on the best quality sites. Sites with a high potential for growing trees generally also have a lower potential for some types of environmental degradation.

Transformation of portions of the species-rich natural forest to low diversity stands is of concern for ecological reasons. The diversity of much of Nova Scotia's forests has been reduced already as a result of past forestry practices, insect outbreaks and fires. Planting stands of spruce and pine will add to the number of species presently available to the softwood industry. Biological diversity, however, will be substantially reduced as it stems from the community interaction of numerous species, including those of no commercial value. For example, stands of so-called "sylvan slums", containing species such as raspberries, alders, wire birch, red maple, and poplar are of great value ecologically. Species such as these, which have no commercial value, are often discounted by foresters, and subsequently not included in their descriptions of forest diversity.

The low biological diversity of plantations stems from the majority of trees in each stand being the same age and species, and the lack of an understory and associated herbs. The accumulation of acidic leaf litter under purely coniferous stands tends to inhibit the growth of other vegetation. The lack of standing dead trees and rotting logs also reduces habitat for wildlife (as dead trees or snags are critical nesting habitat for many forest birds).

Significant problems (mortality and disease) have plagued plantations established in the past in Nova Scotia (Wall, 1975; Roller, 1978). Increased incidences of outbreaks of pests or diseases are generally thought to result from a variety of causes, including increased site dominance by one or two species, reduced genetic diversity and reduced natural selection at the level of the microhabitat.

In Newfoundland, for example, the most severe losses from Armillaria root rot, a disease which affects all tree species, occurred in plantations (CFS Submission to the Newfoundland Royal Commission on Forest Protection and Management). Tree mortality reached 35% due to this disease. Attacks of European pine sawfly have caused severe defoliation in plantations in Newfoundland. Douglas fir needle blight has occurred in five plantations in the Maritimes in which all the trees originated from a single source. Shoot blight has resulted in the destruction of a plantation of red pine at Debert. The white pine weevil is restricting the planting of eastern white pine and Norway spruce in parts of the Maritimes (Environment Canada, 1982). It is obvious that disease and insect problems are found outside plantations as well, particularly where the forest is dominated by even-aged stands of susceptible species.

Therefore, the need for pesticide applications will remain in the managed forest, although the reduced balsam fir component will presumably reduce spruce budworm infestations. As about two-thirds of the annual cutover will not be planted, however, and will likely continue to regenerate frequently to fir in the absence of harvesting methods modified to encourage more desirable regeneration, the budworm problem is unlikely to disappear. Protection requirements may also increase because the considerable economic investment in a plantation makes insect and disease losses even less acceptable.

Plantation establishment may increase the severity and duration of impacts which characteristically result from clearcutting. For example, intensive mechanical site preparation may result in severe and extensive ground disturbances with subsequent increased erosion, nutrient losses and alterations in drainage and stream flow. Stream flows may also increase (Hornbeck and Ursic, 1979) with subsequent erosion of stream banks and stream siltation. Suppression of colonizing broadleaf species which compete with seedlings (or provide cover for small mammals), either through mechanical or chemical site preparation, is also of concern. Broadleaf species rapidly provide ground cover and high rates of primary production, thus minimizing erosion, restoring transpiration, stream flow regulation and nutrient cycling.

Maintenance of pure softwood cover in conifer plantations may therefore limit productivity because of the important ecological role of deciduous trees. In addition, soils become very acidic underneath coniferous stands, with a tendency for the needle litter to tie up nutrients in an unavailable form, thus contributing to nutrient depletion on infertile sites.

Conversion of hardwoods or mixed woods to softwoods may also result in long term reductions in stream flow. This is because conifers have greater interception and transpiration water losses because of their greater total leaf area, compared to hardwoods. Stand conversion elsewhere has resulted in water yield reductions of 20% for long periods (Freedman, 1982).

The environmental impact of IFM has not been assessed in Nova Scotia, although a screening process for new projects being funded by CFS is now in place. There is an urgent need to implement appropriate studies and monitoring activities in order to quantify impacts and develop mitigation measures. Environmental assessment should include site specific consideration of available alternatives, such as harvesting systems which promote natural regeneration, especially as these may be as (or more) economical when compared with IFM.

In the interim, the following measures are suggested to reduce impacts:

(a) Diversity should be maximized by planting small blocks with as many different species as site conditions permit.

(b) Although the use of herbicides or mechanical treatment to reduce the hardwood component of forests below 10-15% stems is probably not economic in Nova Scotia (Winget, 1983), the maintenance of at least this proportion of hardwoods should be actively encouraged in both plantations and the natural forest.

(c) The use of site preparation equipment on sites where soil compaction or erosion will subsequently be a problem should be curtailed.

(d) Alternatives to hardwood suppression, such as the use of larger seedlings, should be investigated, as these require less intensive site preparation.

(e) The need for suppression of broadleaf competition should be evaluated at each site. Guidelines should be developed to minimize the use of herbicides and/or scarification for this purpose.

(f) Buffer strips of natural forest around all streams should be maintained, although regeneration or selective cutting in a buffer strip is acceptable. Plantations should not be established closer to water bodies than the buffer zone requirement for spraying would permit.

(g) Reforestation efforts should not be directed to poor quality sites (e.g., Canada Land Inventory Classes 5, 6, 7).

3.2.8 Economic and Administrative Aspects of IFM

Clearcutting is considered the most economic method of harvesting wood because it results in the greatest short term monetary return. This analysis, however, does not take into consideration the extensive remedial treatments (i.e., reforestation and thinning) required following clearcutting in order to restore cutovers to forest production. With an estimated cost of roughly $500 per acre (1981), in order to establish and maintain a plantation for an economic return 40-60 years in the future, plantation productivity must greatly exceed that of natural stands or ones resulting from shelterwood or strip cutting.

Alternative harvesting methods such as regeneration cutting are sometimes considered more costly because of the greater skill, care and time required during harvesting. In addition, the series of partial cuts within each stand result in economic returns spaced over the rotation period. If the added costs of harvesting techniques that actively promote natural regeneration are unacceptably high, the costs of reforestation may be more prohibitive. For example, Davar and Runyan (1980) evaluated the relative costs of clearcutting, strip cutting and shelterwood for the management of tolerant hardwoods. Clearcutting followed by shelterwood were the best alternatives. However, it was also concluded that clearcutting either with or without subsequent thinning of natural regeneration will likely result in regeneration by low value species and environmental problems such as erosion. The costs of restoring the cutovers to production were not included in the economic analysis.

If the costs of maintaining stand quality (i.e., reforestation in the case of softwood management) were included in the economic analysis of total forest management systems, clearcutting may not turn out to be the least costly alternative. Alternative harvesting methods also tend to result in a greater diversity of species and products, and hence provide a margin of future security and safety. There is, however, no published economic comparison for Nova Scotia. The costs of nurseries, site preparation equipment and the various treatments used in the clearcut and plant scenario have been extensively subsidized by both federal and provincial governments in Nova Scotia. This has masked the total cost of the clearcutting cycle, as operators have not been required to bear the real costs of maintaining forest production.

The arguments supporting clearcutting without regard to regeneration have generally been economic in nature, while those against clearcutting have generally been environmental. We believe that a detailed analysis of the economic and environmental costs of such unmodified clearcutting is overdue. If government subsidies and the total costs of reforestation are considered, other harvesting systems may be both cheaper and more environmentally benign in the long-term.

3.3 AQUATIC EFFECTS OF PESTICIDES

The information in Section 3.3 is a summary of the more significant scientific literature relating to the aquatic effects of pesticides presently used in Nova Scotia or which are used for forestry purposes in New Brunswick. This information is quite technical; nevertheless, we believe that a detailed literature review of the aquatic effects of pesticides is needed to support some of our recommendations. For the chemicals discussed below, however, the public data base is strong enough to reach an adequate assessment of environmental behaviour.

The section begins by describing how pesticides applied to the forest can reach the aquatic environment. It goes on to discuss the role that buffer zones can play in reducing aquatic contamination and examines the size of buffer strip that is desirable. The balance of the section is a literature review on the aquatic fate and effects of herbicides and insecticides used in forestry management.

The pesticides reviewed are 2,4-D, 2,4,5-T, *Bacillus thuringiensis*, fenitrothion and aminocarb. A review of dioxins is included in the section on herbicides. In each case, the available information about toxicity to fish and aquatic invertebrates is discussed. The potential for bioaccumulation is outlined, and the question of where the pesticide ends up in aquatic ecosystems is explored. Information on environmental persistence is also presented, and knowledge gaps are outlined. This section does not contain any information about the human health effects of pesticides, an area in which other agencies have the recognized competence.

A summary of the information in this section is provided in Section 3.4. Inevitably, much information of interest and importance has not been included in the summary.

3.3.1 Pesticide Introduction to Aquatic Environments

Pesticides enter aquatic environments in the following ways: (a) direct application to surface waters; (b) mobilization in ephemeral stream channels; (c) overland flow; (d) leaching; (e) drift from nearby spray areas (Norris, 1981); and (f) wind erosion (NRCC, 1978). Since very small concentrations of pesticide have been detected in precipitation (Pearce *et al.*, 1979), such events may also result in the deposit of trace amounts of pesticide in surface waters.

3.3.1.1 Direct Application to Surface Waters. This route probably has the potential for resulting in the highest concentrations in aquatic systems. As such, it is more important in accounting for acute toxic effects than for chronic effects and is a significant route of entry for a shorter period of time than the other routes discussed.

The aquatic persistence of pesticides is dependent in part on such hydrologic factors as (1) size of the water body, (2) ratio of stream surface area to volume, (3) exchange rate of water, and (4) portion of water body which received a direct deposit. Streams and rapidly moving water bodies are expected to maintain high pesticide residues for shorter periods of time than are slower moving water bodies. Spray operators are always encouraged to avoid direct application of pesticide to water bodies by using skilled applicators and accurate delivery systems.

3.3.1.2 Mobilization in Ephemeral Stream Channels. Very small or ephemeral stream channels are often difficult to see from the air and are very seldom avoided by spray operators. For this reason, if a rain event occurs shortly after a pesticide application, the concentration of pesticide in such stream channels may be relatively high (Aldhous, 1967). Such a mechanism may be important in Nova Scotia, where small and ephemeral streams are common.

3.3.1.3 Overland Flow. When the infiltration capacity of target site soils becomes saturated during precipitation events, it is possible that a considerable amount of surface runoff may occur. Water soluble pesticides or pesticides which have been adsorbed to soil particles that are entrained in runoff may enter aquatic environments. Such a mechanism may be very important on sites that are receiving site preparation herbicides and which have extensive areas of bare or compacted soil.

3.3.1.4 Leaching. Most forestry pesticides, because they are very poorly water soluble and strongly adsorbed to soil particles, are not particularly leachable. Entry of pesticides to non-target environments through this process is, therefore, probably not significant.

3.3.1.5 Drift. The drift of pesticide chemicals has been known for some time to be sufficient to cause non-target damage to susceptible species up to tens of miles away (NRCC, 1978; Reisinger and Robinson, 1976). Research into pesticide drift and its control has, therefore, received a considerable amount of attention. Excellent overviews are contained in Ghassemi et al. (1982), NRCC (1978), Reid and Crabbe (1980), and Warren (1976). It would be fair to say, however, that at this time the phenomenon of pesticide drift is not understood well enough for accurate operational predictions to be made.

Spray drift is probably best defined as that part of the emitted spray which moves out of the target area via atmospheric transport. Spray drift has basically two components, particulate (or spray droplet) drift and vapour drift (Warren, 1976), each of which is affected by a different set of parameters.

The drift of spray droplets is primarily a function of particle size, particle density, release height, wind speed, atmospheric stability, and aircraft turbulence (Crabbe _et al_., 1980; Crabbe _et al_., 1982; Picot _et al_., 1981; Warren, 1976). All of the above factors interact in a complex manner to affect particulate spray drift. Worthy of noting in this context is that the recent results of Crabbe _et al_. (1980) and Crabbe _et al_. (1982) indicate that, contrary to previously held beliefs, increasing atmospheric turbulence decreases the amount of small particle spray drift and increases the amount of particulate pesticide which is impacting the target area. These findings indicate that the practice of spraying in early mornings when atmospheric conditions are stable or near neutral may result in greater spray drift than at times when light winds are creating slightly turbulent conditions. Picot (1980) showed that under conditions of moderate atmospheric stability, the drift of forestry insecticide droplets beyond 300 m downwind of spray lines is usually of the order of 1% of the emitted mass of material. Crabbe (1979) and Crabbe _et al_. (1980) found, however, that due to the evaporation of the carrier and diluent chemicals, most of the more distant drift is active ingredient rather than formulated material. They suggested that 16% of the emitted active ingredient mass is still airborne about 7.5 km away under the same conditions. Ghassemi _et al_. (1982) found that, at 1000 m downwind, anywhere from 0.1 to 5% of the emitted dose (ai) may be deposited.

Forestry insecticide spray droplets are much smaller (mean median diameter 40 - Picot and Kristmanson, 1981) than are forestry herbicide spray droplets (mean median diameter 200 - Warren, 1976) and are, therefore, much more subject to drift. Recent information from a study conducted by EPS in the Atlantic Region (LeBlanc and Ernst, 1982) confirmed that droplet drift is much less for forestry herbicide sprays.

The second component of spray drift, the vapour cloud, may be very important in some cases. The phenoxy herbicides, particularly some of the ester formulations, have been shown to be volatile. A large amount of the mass of the emitted pesticide may therefore be transformed to the vapour phase during its journey from the delivery vehicle to ground, and even after it has been deposited (NRCC, 1978). For this reason, some highly volatile ester formulations of phenoxy herbicides are no longer registered in Canada.

The drift of the vapour portion of the spray cloud is usually greater than the particulate portion and is controlled by factors such as the physical characteristics of the formulation (e.g., volatility), temperature, relative humidity and wind (Gratkowski, 1975; NRCC, 1978). Several authors have suggested a number of measures which may be taken to reduce total spray drift (Ash _et al_., 1982; Gratkowski, 1975; NRCC, 1978; Warren, 1976). These include:

- increasing the size of the emitted droplets, which results in greater sedimentation rates;
- reducing the height to the safest possible in order to decrease the droplet fall distances;
- reducing the volatility of spray formulations by using only low volatility pesticides, and adding invert emulsions and emulsions to increase formulation thickness;
- spraying only under cool temperature and high relative humidity conditions;
- spraying only under conditions of moderate wind and avoiding stable atmospheric conditions; and
- decreasing aircraft speeds to reduce wing and rotor vortexing.

A number of models have been designed to account for the influence of some of the above factors (Ghassemi _et al_., 1982; Picot _et al_., 1980; Picot and Kristmanson, 1981; Reid and Crabbe, 1980), but the predictive capability of these models appears to be low at this time.

3.3.1.6 _Wind Erosion_. The wind erosion of soil particles to which pesticide has been adsorbed may be an important transport mechanism in an agricultural situation (NRCC, 1978); however, in a forestry context it is probably not as important since forestry plots usually have more vegetation cover than do agricultural lands. Overland soil erosion of the type discussed above is thought to be more significant.

3.3.2 Buffer Zones

It has been common practice during forestry spray operations, in Nova Scotia and elsewhere, to establish "no spray" buffer zones around environmentally sensitive areas such as watercourses in an attempt to reduce off-target contamination.

A conflict arises in this regard, however, in that environmental regulatory agencies want to establish buffer zones which will be large enough to provide adequate off-target protection, while resource managers desire that the buffer zones be of minimal size to maximize resource use and protection. The discussion in the previous section indicates, however, that the predictive understanding of off-target movement mechanisms is not sufficient to provide a rigid numerical buffer zone guideline. Buffer zone requirements are dependent on a large number of variables and are usually best addressed on a site specific basis. In the past, the Environmental Protection Service (EPS) through the Atlantic Region Pesticides Advisory Committee (ARPAC) has made recommendations to the Nova Scotia Department of the Environment regarding buffer zones for the protection of surface waters on a case-by-case basis through an established permit review system.

There have been very few studies which document the effectiveness of watercourse buffer zones in reducing incidental deposit of pesticides. Recent unpublished studies by EPS in this region indicate that while a 400 metre buffer zone was sufficient to reduce the incidental deposit of applied pesticide on a lake by up to 92% when compared with a similar lake which had no buffer zone (Ernst et al., 1981), the same buffer zone had no appreciable effect in reducing the deposit of active ingredient on small streams.

In Maine, 500 m buffer zones were effective in reducing the impact on aquatic insects of operational dosages of carbaryl (0.75 lb/acre), however, smaller buffer zones had no effect (Trial, 1980). Interesting to note in this respect is that researchers in Maine (Grantham, 1982) have found that repopulation of the lower reaches of a stream by benthic invertebrates, after biomass depletion due to operational forestry insecticide programs, may be enhanced by excluding the upper reaches of the watershed from spraying.

Studies conducted by EPS (Wilson and Wan, 1975) during aerial herbicide applications employing helicopter mounted spray equipment have determined that buffer zones of 50 metres are sufficient to reduce aquatic contamination. Fixed wing delivery, with its accompanying higher air speeds and greater wing vortexing, would require buffer zone widths in the order of 400 to 500 metres, as indicated above.

The results of recent studies conducted by EPS in the Atlantic Region (LeBlanc and Ernst, 1980, EPS unpublished data) also indicate that vegetation is an important scavenger of aerosol sprays. This is probably an additional incentive for leaving buffer zones of standing timber adjacent to watercourses.

3.3.3 Chlorophenoxy Herbicides

At present, the only effective conifer release or site preparation herbicides which are registered for forestry use in Canada are 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4-dichlorophenoxyacetic acid (2,4-D).

Since their introduction in the late 1940s, there has probably been more research effort directed towards establishing the target and non-target effects of chlorophenoxy herbicides than for any other group of pesticides. It would be most difficult to review all of the environmental effects literature within the constraints of this document. Excellent reviews have been done by A.C.P. (1980), Bovey and Young (1980), C.E.H.V. (1974), C.A.S.T. (1975), E.P.A. (1971), MacKenzie _et al_. (1975), N.R.C.C. (1978) and Pimental and Goodman (1974). No attempt will be made in this section to present an overview of the general environmental effects. In keeping with the EPS mandate, the material presented here will rather be an attempt to focus on the most relevant and recent literature which is available concerning the aquatic behaviour and effects of the phenoxy herbicides and their associated chlorinated dibenzo-_p_-dioxins.

Many of the early investigators were unaware of the importance of trace contaminants in affecting the toxicological nature of 2,4-D and 2,4,5-T, and thus neglected to document the extent to which their test chemicals were contaminated with various dioxin isomers. This, combined with the fact that changing production technology has tended to decrease the dioxin content of marketed product, makes it very difficult, when reviewing the toxicological literature, to separate the effects of the active components 2,4-D and 2,4,5-T from that of their associated dioxins. In this review, wherever possible, the measured or estimated dioxin content of test materials used and the year of the test will be stated. The toxicology and environmental behaviour of 2,3,7,8-tetrachloro-dibenzo-_p_-dioxin (2,3,7,8-TCDD) will be dealt with separately in Section 3.3.3.5.

3.3.3.1 _2,4,5-T, 2,4-D and Fish_. Some of the most sensitive and environmentally relevant species of fish to the acute toxic effects of phenoxy herbicides are salmonids such as rainbow trout (_Salmo gairdneri_), brook trout (_Salvelinus fontinalis_), cut-throat trout (_Salmo clarki_) and Atlantic salmon (_Salmo salar_). Table 3.2 contains representative LC50 values for salmonid fish.

From Table 3.2, it may be seen that the ester formulations of phenoxy compounds are generally more acutely toxic to salmonids than are the amines and acids. Some of the ester formulations are toxic to trout in

TABLE 3.2 - ACUTE EFFECTS OF 2,4-D AND 2,4,5-T ON SALMONID FISH

Compound	Species	Exp. Time (hrs)	LC50 (mg/L)	TCDD Content (μg/g form)	Reference
2,4-D					
PGBE* Ester	*S. gairdneri*	48	1.1	N/A	Bohmont, 1967
BE** Ester	*S. gairdneri*	24	1.5-1.6	N/A	Inglis & Davis, 1972
PGBE Ester	*S. salar*	72	5	N/A	Holland *et al*., 1960
PGBE Ester	*S. gairdneri*	48	1.1	N/A	Cope, 1964
PGBE Ester	*S. gairdneri*	48	0.96	N/A	FWPCA, 1968
PGBE Ester	*S. clarki*	96	0.49	N/A	Woodward & Mayer, 1978
BE Ester	*S. clarki*	96	0.49	N/A	Woodward & Mayer, 1978
BE Ester	*S. gairdneri* (fry)	96	<0.42	N/A	Martens *et al*., 1980
BE Ester	*S. gairdneri* (alevins)	-	-	-	-
2,4,5-T					
Acid	*S. gairdneri*	48	1.3	N/A	Bohmont, 1967
Acid	*S. gairdneri*	24	12.0	N/A	MacKenzie, *et al*., 1975
Triethylamine	*S. gairdneri*	96	0.07-0.72	N/A	Kenaga, 1974
PGBE Ester	*S. gairdneri*	24	0.13	N/A	Kenaga, 1974
Acid	*S. gairdneri*	48	21.9	N/A	Cope, 1965
PGBE Ester	*S. gairdneri*	48	0.65	n/A	FWPCA, 1968
PGBE Ester	*S. gairdneri*	48	1.4	N/A	Walker, 1971

* PGBE = Propylene glycol butyl ether ester.

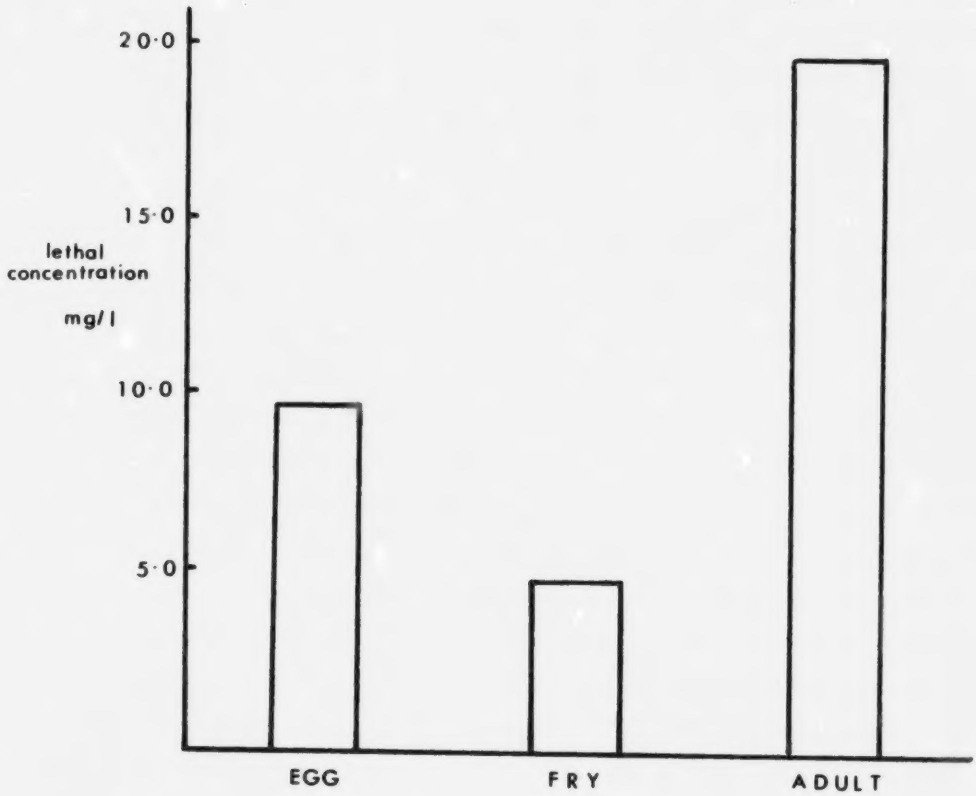
** BE = Butoxyethanol ester.

the 0.5 mg/L range. The greater toxicity of ester formulations may be due to their greater lipid solubility, and thus the greater ease with which they are able to cross membrane barriers (MacKenzie et al., 1975). Due to their efficacy, it is primarily the iso-octyl ester of 2,4-D and the proplyene glycol, butyl ether ester of 2,4,5-T which are used in forestry situations.

Water quality characteristics are also known to modify the toxic potential of organic chemicals in general (Cairns et al., 1975; Fry, 1971; Woodward and Mauck, 1980) and phenoxy herbicides specifically (Vardia and Durve, 1981; Woodward and Mayer, 1978). For example, toxicity studies recently conducted by EPS in the Atlantic Region have indicated that ambient water pH can modify the toxicity of 2,4-D to fish very significantly. These studies demonstrated that 2,4-D acid is approximately 20 times more toxic to rainbow trout (Salmo gairdneri) at pH 4.5 than at neutral (7.0) pH (EPS, Atlantic Region, unpublished data). These results are meaningful in light of the low pH of some natural waters in southwestern Nova Scotia. Decreasing water temperatures have been shown to increase the toxicity of 2,4-D butyl ester and 2,4-D propylene glycol butyl ether ester to cut-throat trout and lake trout (Woodward and Mayer, 1978) and to decrease the toxicity of 2,4-D acid to mosquito fish (Vardia and Durve, 1981). Altering the hardness of water appears to have little effect on phenoxy herbicide toxicity (Woodward and Mayer, 1978; Inglis and Davis, 1972).

As is the case for many toxic materials, the early life stages of fish are often more sensitive to the effects of phenoxy herbicides than are adults. Figure 3.2 illustrates this point. The fry stage may be more sensitive than either the adult or egg stage because at this time the animal is much more metabolically active than the embryo but has not yet developed the enzymes necessary for the degradation and elimination of the chemical.

FIGURE 3.2 - LETHAL CONCENTRATIONS OF FENOPROP (PROPYLENE GLYCOL BUTYL ETHER ESTER OF 2,4-D) TO DIFFERENT LIFE STAGES OF BLUEGILL (*Lepomis macrochirus*)



(Data from Wilbur and Whitney, 1973, and Hughes and Davis, 1963.)

The chronic effect of phenoxy herbicides on the survival of fish has been much less well studied than acute effects. Woodward and Mayer (1978) observed that the survival of cut throat trout alevins was significantly reduced when they were continuously exposed to 44 μg/L 2,4-D (as the butyl ether ester) through the alevin stage of development. Pink salmon, coho salmon and rainbow trout alevins were found to be somewhat more resistent to 2,4-D as the butoxyethyl ester, surviving exposure to 0.22 mg/L from hatching to yolk-sac absorption; however, they were found to be significantly shorter than controls at the termination of the experiment (Martens _et_ _al_., 1980).

The sublethal effects of phenoxy herbicides on fish have also been researched. Dodson and Mayfield (1979) demonstrated that rainbow trout which were exposed to 2,4-D butoxyethanol ester for 24 hours progressively lost their rheotropic response (ability to remain stationary in a flowing current) at concentrations above 2 mg/L. At higher concentrations the fish became lethargic; death resulted at approximately twice the concentration which is used to treat aquatic weeds. McBride _et_ _al_. (1981) observed that juvenile sockeye salmon (_Oncorhynchus_ _nerka_) demonstrated histopathological changes in the kidneys when exposed for 48 hours to a concentration of 2,4-D butoxyethanol ester (0.7 mg/L) only marginally below the lethal level. These changes were reversible when the fish were transferred to clean water. In the same experiment, the fish demonstrated elevated plasma cortisol (a "stress" hormone) after 1 hour exposures to 5 mg/L of the herbicide. In longer term exposures (2-5 weeks) to redear sunfish (_Lepomis_ _microlophus_), fenoprop, another chlorophenoxy herbicide, has been shown to cause liver and testicular degeneration and abnormal spermatozoa at concentrations above 3 mg/L (Elkin, cited by NRCC, 1978).

Studies of the effects of phenoxy herbicides on fish enzyme systems have indicated that these chemicals are hydrolyzed by the enzymes in liver and gills (Chambers _et_ _al_., 1977), one of the primary mechanisms for detoxification. Phenoxy herbicides have also been shown to inhibit liver succinic oxidase and alpha-ketoglutarate oxidase activities in vitro (Hiltibran, 1972 a), and the ability of phenoxy herbicides to inhibit the hydrolysis of ATP (Hiltibran, 1972 b) may be a major toxic effect.

While a number of secondary toxic effects of phenoxy herbicides, such as neurotoxicity, mutagenicity, teratogenicity, carcinogenicity, embryotoxicity and immunosuppression may be evident in mammalian and bird species (NRCC, 1978), few of these effects have been specifically investigated in fish. Matlak (1972) did observe delayed hatchings in carp (Cyprinus carpio) exposed to sublethal concentrations of 2,4-D sodium salt and certain abnormalities (hydrocoele embryonalis, deformations of spinal cord and swollen yolk sac) in some of the treated larvae. Rosenthal and Stelzer (1970) also observed that 2,4-dinitrophenol, a breakdown product of 2,4-D, produced abnormal heart activity and malformations (anophthalmy, symetrical and unilateral microphthalmy, curled bodies and de-differentiations) in herring (Clupea harengus) which were exposed to sublethal concentrations during the egg stage.

3.3.3.2 2,4-D, 2,4,5-T and Aquatic Invertebrates. Most of the available literature indicates that phenoxy herbicides are moderately acutely toxic to aquatic invertebrates (Table 3.3). As is the case with aquatic vertebrates, the ester formulations are more toxic to aquatic arthropods than are other formulations (NRCC, 1978). LC50s range from 0.1 to 16.4 mg/L.

The sublethal effects on invertebrates have been much less studied than acute lethal responses. Butler (1965) reported inhibition of shell growth in oysters exposed to concentrations of 1.0 mg/L 2,4-D as the propylene glycol butyl ether ester and 0.14 mg/L 2,4,5-T as the propylene glycol butyl ether ester for 96 hours. The same author observed that adult brown shrimp (Penaeus aztelus) were partially paralyzed after a 48 hour exposure to 59.2 mg/L 2,4-D acid or amine, and 1 mg/L 2,4,5-T propylene

TABLE 3.3 - LETHALITY OF 2,4-D AND 2,4,5-T TO AQUATIC INVERTEBRATES

Chemical	Formulation	Species	Exposure Time (hrs)	LC50 mg/L	Reference
2,4-D	Butoxy ethanol ester (BEE)	Gammarus lacustris	24	1.4	Sanders, 1969
2,4-D	Propylene glycol butyl ether ester (PGBEE)	Gammarus lacustris	24	2.1	Sanders, 1969
2,4-D	Iso-octyl ester (IE)	Gammarus lacustris	24	6.8	Sanders, 1969
2,4-D	PGBEE	Daphnia magna	48	0.10	Sanders, 1970
2,4-D	BEE	Daphnia magna	48	5.6	Sanders, 1970
2,4-D	PGBEE	Gammarus fasciatus	48	2.6	Sanders, 1970
2,4-D	BEE	Gammarus fasciatus	48	5.9	Sanders, 1970
2,4-D	PGBEE	Cypridopsis vidua	48	0.32	Sanders, 1970
2,4-D	BEE	Cypridopsis vidua	48	4.9	Sanders, 1970
2,4-D	BEE	Pteronarcys californica	96	1.6	Sanders and Cope, 1968
2,4-D/ 2,4,5-T	Butyl glycol esters (BGE)	Gammarus pulex	96	2.3	Seuge *et al.*, 1978
2,4-D/ 2,4,5-T	BGE	Cleon sp.	96	3.0	Seuge *et al.*, 1978
2,4-D/ 2,4,5-T	BGE	Lymnea sp.	96	10.6	Seuge *et al.*, 1978
2,4-D/ 2,4,5-T	BGE	Chaoborus sp.	96	16.4	Seuge *et al.*, 1978

glycol, butyl ether ester. Increasing exposure temperature increases the toxicity of 2,4-D salt to Daphnia magna (Presing, 1981) and of 2,4-D and 2,4,5-T butoxyethanol ester to Chironomus larvae (Sigmon, 1979). Presing also observed reproductive inhibition in the sublethally exposed Daphnia.

3.3.3.3 Secondary Effects. The foregoing discussion dealt with the direct toxicological effects of phenoxy herbicides on aquatic organisms. These may be considered the primary effects. There are also a number of effects which have been postulated or observed for phenoxy herbicides which may be called secondary effects. These are ecosystem changes and are a result of the primary effects. Hurlbert (1975) reviewed the secondary effects of pesticides on aquatic ecosystems and suggested that herbicides have a greater potential to cause secondary effects than do insecticides, due to their effects on primary production by phytoplankton and aquatic macrophytes.

The sequela of secondary events which may occur after a herbicide treatment directly to a water body or as a result of terrestrial treatments is presented in Figure 3.3. It should be recognized that this figure indicates ecological effects many of which are not supported by empirical evidence at present. Unfortunately, up to this point the most serious drawback to generating such supportive evidence is the fact that it has been impossible to separate the ecological effects of herbicide introduction to aquatic systems from the normal temporal changes which are associated with natural succession.

Table 3.4 contains some of the observation of various investigators who attempted to determine the overall ecological effects of herbicide treatment of aquatic systems at concentrations which would simulate those used for aquatic weed control. This table serves to indicate that the secondary ecological effects of introducing phenoxy herbicides into aquatic systems may depend on initial dosage rates and site specific considerations (NRCC, 1978).

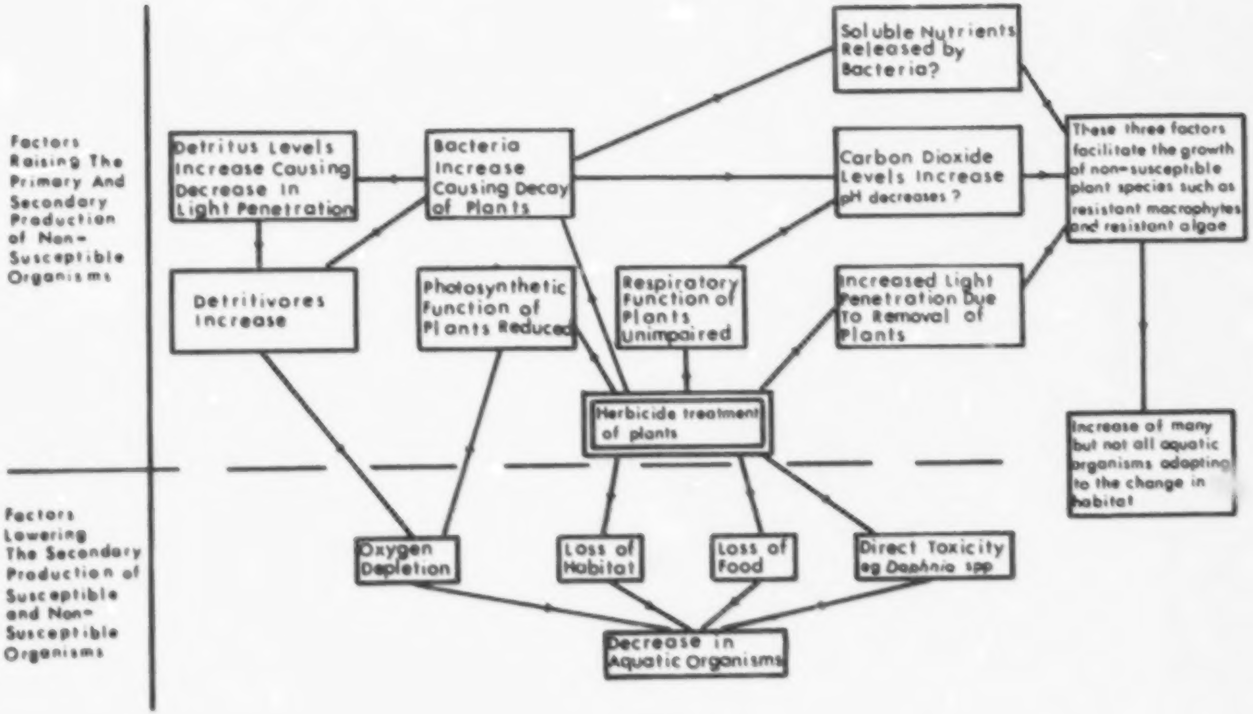

Factors Raising The Primary And Secondary Production of Non-Susceptible Organisms
Factors Lowering The Secondary Production of Susceptible and Non-Susceptible Organisms
Detritus Levels Increase Causing Decrease in Light Penetration
Bacteria Increase Causing Decay of Plants
Soluble Nutrients Released by Bacteria?
Carbon Dioxide Levels Increase pH decreases ?
These three factors facilitate the growth of non-susceptible plant species such as resistant macrophytes and resistant algae
Detritivores Increase
Photosynthetic Function of Plants Reduced
Respiratory Function of Plants Unimpaired
Increased Light Penetration Due To Removal of Plants
Herbicide treatment of plants
Increase of many but not all aquatic organisms adapting to the change in habitat
Oxygen Depletion
Loss of Habitat
Loss of Food
Direct Toxicity eg Daphnia spp
Decrease in Aquatic Organisms

FIGURE 3.3 - POSSIBLE SHORT-TERM ECOLOGICAL EFFECTS OF HERBICIDES IN AQUATIC SYSTEMS (Newbold, 1975)

TABLE 3.4 - SECONDARY AQUATIC EFFECTS WHICH HAVE BEEN DOCUMENTED IN ASSOCIATION WITH PHENOXY HERBICIDE TREATMENT

Chemical	Formulation	Treatment	Dosage Rate or Concentration	Effects	Author
2,4-D	Propylene glycol butyl ester ester (PGBEE)	Directly to Pond	10 mg/L ai	Oxygen concentrations - decreased from 6.2 to 2.5 mg/L within 2 days. Lowered pH and carbonate, increased carbon dioxide concentrations - increased from non-detectable to 50.8 mg/L. Increased bluegill growth.	Cope *et al*., 1970
2,4-D	Amine	Directly to Reservoir	45 kg/ha ai	Oxygen concentrations - decreased from 10-13 mg/L to 5.9-6.6 mg/L in 2-4 weeks. pH decreased from 8.4 to 6.4. Decreased light penetration. Elimination of Cladocera, Diptera, Lepidoptera and some snail species.	Wojtalik *et al*., 1971
Fenoprop	PGBEE	Directly to Pond	2 mg/L ai	Reduction in zooplankton for 2 weeks following application.	Pierce, 1959
2,4-D	Butoxyethanol ester (BEE)	Directly to Pond	2.6-3.6 mg/L ai	Reduction in phytoplankton and zooplankton 1-2 weeks post treatment.	Pierce, 1961

.../2

TABLE 3.4 - (Continued)

Chemical	Formulation	Treatment	Dosage Rate or Concentration	Effects	Author
2,4-D	BEE	Directly to Pond	112 kg/ha ai	Destruction of aquatic plants (Myriophyllum) and associated insects (dragonfly, caddisfly, mayfly larvae and riffle beetles.	Smith and Isom, 1967
Fenoprop	Potassium Salt	Directly to Pond	2.8-4.6 mg/L ai	Generation of hydrogen sulfide from decaying vegetation, anaerobic conditions, increases in low O_2 tolerant, oligochaete and chironomid species. Decreases in Chaoborus and Libellulids. Increase in total benthic biomass.	Harp and Campbell, 1964
Fenoprop	PGBEE	Directly to Pond	9 kg/ha ai	Increase in total benthic biomass.	Pierce, 1962
2,4-D	BEE	Directly to Estuaries	34 kg/ha ai	Increase in marine benthos (Mytilus, Nereis, Macoma).	Thomas and Duffy, 1968

.../3

TABLE 3.4 - (Continued)

Chemical	Formulation	Treatment	Dosage Rate or Concentration	Effects	Author
2,4-D	BEE	Directly to Estuaries	Unstated	Decrease in benthic faunal species diversity.	Haven, 1963
Fenoprop	Unstated	Directly to Pond	Unstated	Decreased growth of three bluegill species.	Houser, 1963

No literature could be found which documented ecological effects of introducing phenoxy herbicide to aquatic environments through routes such as off-target movement.

3.3.3.4 Residues. The question of the non-target effects of any pesticide is of course related to the concentration which may be expected to reach susceptible components of the environment. Initially, herbicides which are used in forestry operations are able to reach the aquatic environment as a result of direct overspraying, aerial drift from target areas, mobilization through ephemeral stream channels, overland flow and subsurface leaching. Incidental deposit may also result from accidental spills.

Table 3.5 contains the calculated immediate concentrations of 2,4,5-T which may be expected after direct application of 2,4,5-T to a water body. The assumptions inherent in this calculation are that the entire emitted dose is deposited on the target and that the deposited pesticide is uniformly mixed throughout the water column with no partitioning in any component of the environment. These are obviously unrealistic assumptions and intuitively the values presented are probably the maximum instantaneous herbicide concentrations which would ever occur after operational programs. The table does serve to demonstrate that at dosage rates of between 1.8 to 6.7 kg/ha (the normal forestry dosage range) the theoretical concentrations of pesticides in water bodies are in the range at which effects have been observed.

Such high levels are not, however, usually observed during operational monitoring programs. Probably the highest residues of 2,4-D reported after a forestry application were those found by Aldhous (1967), who observed 1.5 to 2.0 mg/L in drainage ditches up to seven days after application of the nonyl ester at a rate of 4.5 kg/ha. Lawson (1976) also observed 2,4,5-T concentrations as high as 2.2 mg/L in ephemeral streams up to 17 days after the experimental spraying of 4.48 kg/ha 2,4,5-T by

TABLE 3.5 - CONCENTRATION OF 2,4,5-T EXPECTED IN THE WATER COLUMN AFTER DIRECT APPLICATION AT VARIOUS DOSAGES (from Committee on the Effects of Herbicides in Vietnam, 1974)

Dosage Rate (kg/ha)	Water Column Concentration (mg/L)		
	3 Inch Depth	1 Foot Depth	3 Foot Depth
1.12	1.48	0.37	0.12
1.80	2.37	0.59	0.19
6.74	8.88	2.22	0.73
10.44	13.76	3.44	1.15
13.47	17.76	4.44	1.38

backpack. Norris (1967) and Sears and Meehan (1971) have also documented 2,4-D concentrations in the 0.2 to 1.0 mg/L range after operational forestry herbicide programs. Worthy of note is that the latter authors measured these high concentrations of pesticides in a stream which was "protected" by a 30 m unsprayed buffer strip, the contamination apparently being attributed to direct deposit in small tributary streams. Norris (1981) indicated that such high concentrations in water are not the norm, however, and cited data compiled by the U.S. Forest Service which showed that, from a total of 680 samples taken during operational monitoring programs, 84% did not contain measureable herbicide residues, 14% had residues up to 0.005 mg/L, 1% had between 0.005 and 0.01 mg/L and 1% contained more than 0.01 mg/L.

The longevity of 2,4-D and 2,4,5-T in surface water systems does not appear to be great, residues usually being reduced to non-detectable levels within several days to several months, depending upon certain water characteristics (Norris, 1981). Not surprisingly, pesticide concentrations disperse in moving water systems more quickly than they do in standing water due to transport from a particular site (NRCC, 1978). Other environmental factors which affect the rate of phenoxy herbicide loss from water include temperature, oxygen concentration, pH, light intensity, the particular types of micro-organisms which are present and organic content (Norris, 1981). It is not clear at the present time what the relative importance of each of the above factors is in causing the disappearance of phenoxy herbicide from water. Aerobic microbial activity is thought to be one of the more important. For this reason colder, deoxygenated or anaerobic waters maintain phenoxy herbicide residues for greater periods of time (Demarco et al., 1967). Phenoxy herbicides in sterile media last a long time (NRCC, 1978).

Hydrolysis, also an important breakdown process, is controlled by the ambient pH (Norris, 1981). Since hydrolytic degradation rates decrease with decreasing pH, the recent trend to declining ambient water pH in northeastern Canada may be significant in prolonging the life of phenoxy herbicides in surface waters. That this may be a significant factor is evidenced by the observation of Zepp et al. (1975) that at pH 9.0, the hydrolytic half lives of various 2,4-D esters ranged from 1.1 hour to 37.0 hours and at pH 6.0 the hydrolytic half lives for the same esters ranged from 44 to 1500 days. Hydrolysis is also an important factor in that the more toxic ester forms are hydrolyzed to less toxic acids or salts, a process responsible for reducing the potential impacts on aquatic organisms.

Light also has an effect on the breakdown of phenoxy herbicides in aqueous solutions. Ultraviolet wave lengths appear to be most important in the photodecomposition process (Crosby and Tutass, 1966) and 2,4-D is broken down somewhat faster than 2,4,5-T (Crosby and Wong, 1973). Photodecomposition is also pH dependent occurring more rapidly at higher pHs (Crosby and Wong, 1973). Volatilization of phenoxy herbicides from surfaces on which they have been deposited is an important route for their disappearance, particularly for the ester formulations (Grover et al., 1972). The extent to which this process is active in aquatic systems is unknown.

Adsorption and desorption also directly influence herbicide availability, mobility and degradation. Phenoxy herbicide esters are known to adsorb readily to suspended particulate material. The degree and strength of adsorption increases with the number of carbon atoms in the alcohol moiety (Norris, 1981). The adsorption of phenoxy herbicides has been shown to be very pH dependent, being nil or even negative at near neutral or basic pH levels, moderate at pH values near the pKa value for the particular chemical; and very positive at low pH (NRCC, 1978). Adsorption and desorption are also different with various substrate types. The greater the organic content of the substrate the tighter the chemicals seem to be bound (Grover, 1977; Grover and Smith, 1974). Some authors have indicated that desorption of deposited herbicides from soils into runoff may be a major route of entry into surface water (Grover, 1977; Norris, 1970; Harter and Ahlrichs, 1969; Yokim et al., 1978), but the results of other researchers disagree (Harris and Warren, 1964). In turbulent flowing streams, adsorption is expected to be a significant factor in the disappearance of chemical from the water column (Norris, 1981), but Bailey et al. (1968) have observed that the adsorptive capacity of still pond water is limited by the sediment-water interface and that adsorptive capacity may be saturated if herbicide concentrations exceed 2 mg/L.

It is obviously difficult to differentiate between pesticide adsorption and pesticide accumulation in the case of biota. Aquatic plants, particularly phytoplankton, have been observed to accumulate significant quantities of 2,4-D and 2,4,5-T (Smith and Isom, 1967; Soderquist and Crosby, 1975; Wojtalik et al., 1971; Yokim et al., 1978). The latter authors documented 2,4,5-T concentrations in algae and Daphnia which were more than an order of magnitude greater than the ambient water concentrations. The results of Wojtalik et al. (1971) would seem to indicate that almost all of the available pesticide may be taken up by plankters.

The concentration factors in various biota are greater for the ester formulations than for the acids and salts, primarily due to their greater lipid solubility (NRCC, 1978). For example, Kenaga (1974) determined that the octanol/water partition coefficient (a measure of lipid solubility) for 2,4,5-T acid is 0.533 at pH 7 and is 64,000 for the mixed butyl esters at the same pH. It is, therefore, probable that the ester formulations of phenoxy herbicides may be bio-concentrated, but since the esters are rapidly metabolized to acids and may be rapidly excreted (NRCC, 1978), bio-magnification through different trophic levels should not occur. Critical aquatic biota are phytoplankton, aquatic plants, and filter feeding fauna.

Mussels obtained from an area which was treated with 1.12 kg/ha of 2,4-D ester contained up to 0.7 mg/kg, probably a reflection of their consumption of phytoplankton which had concentrated the herbicide (Smith and Isom, 1967). Fish do not appear to collect substantial parent residues of phenoxy herbicides (Yokim et al., 1978; Isensee, 1978 cited in NRCC, 1978; Metcalf and Sanborn, 1975) and clearance is rapid upon transfer to clean water (Yokim et al., 1978).

3.3.3.5 Polychlorinated dibenzo-para-dioxins (PCDDs). The polychlorinated dibenzo-para-dioxins (PCDDs) are a class of organochlorine contaminants which consist of 75 possible different congeners which have a common dibenzo-para-dioxin nucleus. There are a number of proposed and documented sources of dioxins, most of which involve unintentional production during chemical synthesis (Esposito, 1980). Probably the most important known source of PCDDs is in the production of polychlorinated phenols and their derivatives, which include 2,4-D, 2,4,5-T, pentachlorophenol and hexachlorophene (NRCC, 1981). PCDDs are generated as by-products during the synthesis of polychlorinated phenols when chlorinated benzenes are treated with high temperature, high pressure or high alkalinity (Bovey and Young, 1980).

The presence of PCDD in chlorophenoxy herbicides first received wide scale attention in the late 1960s, when it was acknowledged that the military defoliant used in South Vietnam was contaminated with 2,4,7,8-tetra isomer (2,3,7,8-TCDD). This isomer was known at the time to have a wide range of toxic effects at extremely low doses, and was known to be the cause of "Chick Edema Disease", a fatal disease in chickens which was the result of ingesting feed contaminated with 2,3,7,8-TCDD (Bovey and Young, 1980). While the levels of 2,3,7,8-TCDD in the mixed butyl ester combination of 2,4-D and 2,4,5-T which was used in Vietnam ranged from 0.1 to 47 μg/g (Rappe, 1978 a), commercially available 2,4,5-T may have been slightly less contaminated (Rappe, 1978 b). Woolson (1972) analyzed samples of 2,4,5-T that were used in the Vietnam conflict and domestically and determined that 76% of the samples contained less than 0.1 μg/g TCDD, 17% contained 0.1 to 1.0 μg/g TCDD and 9% contained greater than 10 μg/g. Since February, 1979, in Canada, the amount of 2,3,7,8-TCDD in commercially available 2,4,5-T may not exceed 0.1 μg/g as specified by regulations under the pest Control Products Act.

Prior to 1980, 2,4-D formulations were thought to contain few, if any, PCDDs (Woolson et al., 1972; Rappe et al., 1978 b) based on the belief that synthesis techniques (i.e., lower temperatures) for 2,4-D should not produce PCDDs. In 1980, however, the results of a detailed Agriculture Canada survey were released, which indicated that certain 2,4-D formulations contained measurable quantities of PCDDs (Cochrane et al., 1980). These results demonstrated that 2,4-D esters and amines were found to contain di-tri- and tetra-chlorobenzo-p-dioxins exceeding 7 μg/g in some formulations. The ester formulation contained the highest concentration and largest number of PCDD isomers. The tetra isomer identified was the 1,3,6,8 isomer, which is much less toxic than the 2,3,7,8 isomer. Based on these findings, a ban has been placed on the sale by manufacturers of technical esters of 2,4-D containing high concentrations of PCDDs. The present limit placed on commercially available 2,4-D is 0.01 ppm of any specific dioxin isomer (Agriculture Canada, 1981).

The fact that both 2,4-D and 2,4,5-T have been shown to contain PCDDs may mean that some of the toxic effects of the phenoxy herbicides are attributable to low level contamination by PCDDs. In order to assess this possibility, a brief review of the aquatic environmental behaviour and effects of PCDDs follows.

Fish: The only information available on the toxicity of dioxins to fish concerns the toxic effects of 2,3,7,8-TCDD. Table 3.6 indicates that 2,3,7,8-TCDD is extremely toxic to fish and that ambient water exposure is more important than dietary exposure in producing acute lethal effects. Although there is a delay of 10 to 80 days from the time of

TABLE 3.6 - LETHAL EFFECTS OF 2,3,7,8-TCDD TO FISH

Test Species	Exposure Concentration	Exposure Duration	Mortality	Reference
Coho Salmon (Oncorhynchus kisutch)	56.0 ng/L	24 hours	100%	Miller et al., 1973
	5.6 ng/L	24 hours	55%	Miller et al., 1973
	0.56 ng/L	24 hours	12%	Miller et al., 1973
	0.056 ng/L	24 hours	12%	Miller et al., 1973
Guppies (Poecilia reticulata)	0.1 ng/L	120 hours	100%	Norris and Miller, 1974
Rainbow Trout (Salmo gairdneri)	21 μg/kg bw/d Diet	30-40 days	50%	Hawkes and Norris, 1977
Pike Yolksac-Fry (Esox lucius)	10 ng/L	96 hours	80%	Helder, 1980

exposure to the onset of mortality, the critical exposure period is less than 24 hours (Miller et al., 1975; Miller et al, 1979).

Miller et al. (1975) observed that the threshold response level for growth and survival of young coho salmon exposed to 2,3,7,8-TCDD in water for periods up to 96 hours is between 0.54 and 5.4 ng/g (dosage rates = total amount of TCDD added to test solutions/total weight of fish in test chamber).

Aquatic Organisms Other than Fish: There is a paucity of data concerning the toxic effects of dioxins on lower trophic level aquatic organisms. A single reference (Miller et al., 1973) indicates that a concentration of 0.2 μg/L 2,3,7,8-TCDD in water had no effect on pupation of mosquito larvae (*Aedes aegypti*) in 17 day exposures, but reduced the reproductive success of a pulmonate snail (*Physa* sp.) in 36 day exposure periods and oligochaete worms (*Paranais* sp.) in 55 day exposures.

Chronic/Sublethal Effects of PCDDs: While there are few data available which document the chronic or sublethal effects of PCDDs on aquatic organisms, there is certainly no shortage of such information for terrestrial animals. Reviews of such effects are contained in Esposito et al., 1980; Bovey and Young, 1980; and NRCC, 1981.

Table 3.7 lists some of the effects which have been observed as a result of 2,3,7,8-TCDD exposure in various terrestrial animal species. Such effects may or may not be demonstratable for aquatic species, however.

Fate and Persistence of PCDDs in the Aquatic Environment: PCDDs are extremely insoluble in water (about 0.0002 mg/L - Norris, 1981) and are therefore not expected to be leached once they are deposited on adsorptive surfaces. Direct application, drift, or erosion are expected to be the most important routes of entry into the environment for PCDDs in association with phenoxy herbicides (Isensee, 1978; Norris, 1981).

TABLE 3.7 - ANIMAL DYSFUNCTIONS WHICH HAVE RESULTED FROM 2,3,7,8-TCDD EXPOSURE

Dysfunction or Effect	Author
Hepatic	Gupta et al., 1973 Van Miller et al., 1977
Renal	Anazai and Cohen, 1979 Hook et al., 1978
Endocrine	Piper, 1979 Barsotti et al., 1979 Gustafsson and Ingelman-Sundberg, 1979
Immunologic	Faith and Luster, 1977 Vos, 1978 Luster, 1979
Hematologic	Allen, 1962 Weissberg and Zinckl, 1973 Zinckl et al., 1973
Gastrointestinal	Ball and Chabra, 1977 Madge, 1977
Neuropsychiatric	Purkyne, 1974 Elovaara, 1977
Teratogenic	Neubert and Dillman, 1972 Moore et al., 1973 Smith et al., 1976
Carcinogenic	Van Miller et al., 1977 Kociba et al., 1978
Mutagenic	Hussain et al., 1972 Seiler, 1973 Michigan Critical Materials Register, 1979

Table 3.8 (Miller et al, 1973) indicates the calculated concentration of TCDD in stream water after a direct application of 2,4,5-T contaminated with TCDD. Such a calculation is based on the unrealistic assumption that deposited chemicals are immediately and uniformly mixed throughout the water column, with little or no decomposition or partitioning occurring. It does, however, serve to indicate the range of possible TCDD concentrations in past applications. Canadian regulations would now limit the concentration of TCDD to 0.01 ppm.

Due to its highly adsorptive characteristics, 2,3,7,8-TCDD preferentially partitions to aquatic sediments and suspended particulate matter (Ward and Matsumura, 1978; Yokim et al., 1978). Increasing the organic content of the adsorbent increases the bonding strength (NRCC, 1981).

The disappearance of PCDDs from aquatic systems may be related to a number of naturally occurring processes, including photodecomposition, microbial degradation, and volatilization (NRCC, 1981).

Photodecomposition is probably an important route for the disappearance of 2,3,7,8-TCDD when the chemical exists in thin films, such as on the surfaces of vegetation or soils (Crosby and Wong, 1977) or in organic solvents (Crosby et al., 1971; Stehl et al., 1973; Botre et al., 1978). The process is probably of little importance in water and sediments (Esposito et al., 1980).

The importance of microbial degradation in PCDD disappearance is hard to assess; however, the information available suggests that PCDDs are highly resistent (Ward and Matsumura, 1978; Klelka and Gibson, 1980). TCDD appears to be unaffected even by microbial species which have a demonstrated ability to degrade persistent pesticides (Matsumura and Benezet, 1973).

TABLE 3.8 - ANTICIPATED TCDD IN STREAM WATER AFTER AERIAL APPLICATION OF 2,4,5-T (from Miller _et al_., 1973)

2,4,5-T Concentration in Stream Water (ppm)	TCDD Concentration (ppt)	
	Level 1*	Level 2**
1.0	0.05	0.1
0.1	0.005	0.01
0.05	0.0025	0.005
0.01	0.0005	0.001
0.005	0.00025	0.0005

* Level 1: 2,4,5-T contains 0.05 ppm TCDD.

** Level 2: 2,4,5-T contains 0.1 ppm TCDD.
The Canadian limit is 0.01 ppm.

Volatilization is probably the primary known removal route for 2,3,7,8-TCDD in aquatic systems (NRCC, 1981), but this process has not been well defined.

Ward and Matsumura (1978) determined that the half-life of 2,3,7,8-TCDD in sediment incubated in the laboratory, underwater and in anaerobic conditions, was approximately 600 days. The concentrations used (0.7 to 1.8 mg/kg) were about 10^6 times greater than would be expected in this matrix from normal rates of 2,4,5-T application. Another group of researchers (Yokim et al., 1978) reported that 2,3,7,8-TCDD has a half-life in sediment of approximately 300 days under similar conditions. While this information suggests that PCDDs bound up in organic detritus and sediment will remain there for some time, they may be unavailable for direct biological uptake (G.L.S.A.B., 1980).

The ratio of lipid/water solubility for 2,3,7,8-TCDD is approximately 0.2×10^6 (by comparison the same ratio for DDT is 86×10^6, Norris, 1981). This fact suggests that 2,3,7,8-TCDD should have the potential to bio-accumulate. This is supported by evidence which indicates that animals which ingest TCDD will accumulate body burdens about 10 times the dietary concentration (Norris, 1981).

A number of researchers have observed bio-accumulation of 2,3,7,8-TCDD during short term studies in aquatic microcosms. The bio-concentration factors which these authors report range from 1.5×10^3 to 63×10^3 for various aquatic species, including: brine shrimp (Matsumura and Benezet, 1973); mosquito fish, fingerling channel catfish, algae, duckweed, snails, and water fleas (Isensee and Jones, 1975); water fleas, fish, algae, and snails (Yokim et al., 1978).

Aquatic animals clear residues of 2,3,7,8-TCDD much more slowly than terrestrial animals. For example, Miller et al. (1979) found that young coho salmon retained up to 48% of the TCDD originally placed in the exposure chamber after 114 days in clean water.

Unfortunately, very limited monitoring of PCDD residues in environmental samples has taken place after operational use of phenoxy herbicides. The greatest impediments to such monitoring are the difficulty and high cost of analyzing PCDDs with acceptable detection limits. In the monitoring activity which has taken place, substantial dioxin residues have not, however, been detected in aquatic environmental matrices (Norris, 1981).

3.3.4 Bacillus thuringiensis (B.t.)

Generally, biological control agents have been considered intrinsically "softer" in terms of non-target environmental impacts associated with their use. For this reason, there has been much less research effort devoted to elucidating biological control agents' non-target effects, than in determining the same effects for what are perceived as "harsher" chemical control agents.

3.3.4.1 Effects on Fish. There have been very few reports concerning the toxic effects of commercially available *Bacillus thuringiensis* (B.t.) formulations on aquatic vertebrates. The studies done so far have assessed the toxicity of B.t. (var. kurstaki) formulations added to exposure solutions. These studies indicate that the formulation LC50s for salmonid species range from 50 mg/L in 48 hours to greater than 1000 mg/L in 96 hours (NRCC, 1976). A closely related variety of B.t. (var. israelensis) has been shown to be non-lethal to a variety of non-target aquatic organisms including frogs (*Hyla regilla*), toads (*Bufo* sp), newts (*Taricha torosa*), mosquitofish (*Gambusia affinis*), killifish (*Lucania parva*) and twospine stickleback (*Gasterosteus wheatlandi*) at concentrations 50 to 5000 times the concentration which is lethal to mosquito larvae (*Culex pipiens*) (Garcia *et al*., 1980).

Probably a more important route of entry for B.t. to fish would be through the ingestion of contaminated insects, such as knocked-down budworm, in which spores have been activated, are replicating and producing toxins. Bioassays on fish using oral dosing techniques do not appear in the literature.

No impacts on fish have been observed during operational B.t. programs (Buckner _et al_., 1974; Todd and Jackson, 1961).

There has also been a considerable amount of research interest in the effectiveness of spray mixtures which contain B.t. in combination with chemical insecticides, formulations which appear to have good potential for operational control of forest defoliators (Morris, 1977 a; Morris, 1977 b). Aquatic toxicity information has not been developed for B.t./chemical insecticide mixtures, however, and such information should be a prerequisite of operational use.

3.3.4.2 _Effects on Aquatic Invertebrates_. Quite early in insect toxicity studies of B.t., it was shown that some preparations were toxic not only to the usual target Lepidoptera but also to a number of insects in other orders (Burges, 1980). These formulations were later found to contain a beta-endotoxin which was responsible for the non-target toxicity. Present B.t. formulations employ a strain of bacteria which does not produce the beta-endotoxin and which are reported to be quite specifically toxic to only the order Lepidoptera (Lacey and Mulla, 1977; Hall _et al_., 1977; Nishiitsutsuji and Endo, 1980; NRCC, 1978).

There have been some reports, however, that B.t. preparations are very toxic to more beneficial invertebrate species such as earthworms, _Lumbricus terrestris_ (Smirnoff and Heimpel, 1961) and the parasporal crystal produced by B.t. (var. kurstaki) has been shown to be toxic to mosquito larvae, _Aedes taeniorhynchus_ (Yamamoto and McLaughlin, 1981).

Other varieties of B.t. (var. israelensis) are known to be very effective against certain aquatic diptera larvae (Molloy and Jamnback, 1981). The studies which have been done to date have indicated, however, that concentrations of B.t. (var. israelensis) which are effective against biting fly and mosquito larvae do not adversely affect other aquatic insects (Colbo and Undeen, 1980; Miura et al., 1980).

Field investigations so far conducted have not revealed significant impacts on aquatic invertebrates during large scale aerial applications of B.t. (var. kurstaki) (Buckner et al., 1974; Buckner and Sarrazin, 1975; Smith et al, 1979; Todd and Jackson, 1961). All of these studies have, however, had self-admitted limitations. Laboratory toxicity studies on aquatic invertebrates are entirely lacking.

3.3.4.3 Fate and Persistence of B.t. in the Aquatic Environment. Biological control agents have the potential to replicate and grow in the natural environment, a hazard additional to those inherent in the use of chemical control agents. This capability, plus the ability to produce toxins, sporulate and possibly mutate, makes it very important to know critical paths and fate in the environment.

Unfortunately, the fate and persistence of B.t. in aquatic systems is not well known. Studies done by the Environmental Protection Service in the Atlantic Region indicate that chlorination of fresh water at the conventional drinking water treatment rate (0.5 ppm Cl_2 for 30 minutes) did not inactivate B.t. which was present (A. Menon, pers. comm., 1981). At the same time it was determined that B.t. (var. kurstaki) was able to survive in natural fresh and marine waters for up to 100 days at 20°. After large scale aerial applications, Buckner et al. (1974) determined that river water contained high B.t. concentrations shortly after spraying, but that no viable spores were found in the same river one month after application. During large scale aerial applications of B.t. (var. kurstaki) in Nova Scotia, monitors were able to detect elevated B.t. concentrations in stream water eleven days after the treatment (Smith et al., 1979).

No investigators have determined the extent and persistence of B.t. contamination in aquatic sediments after aerial applications or in the laboratory. This may be particularly important where highly organic sediments provide a potential food source and the bacteria are shielded from ultraviolet radiation, which is thought to be the primary destructive mechanism (Griego and Spence, 1978).

Some information is available on the persistence of B.t. in soils. These results indicate that under certain conditions, both spores and endotoxin remain after several months (Fedorincik, 1972; Saleh et al., 1970). Crystal activity is probably longer lived than is spore viability (Morris, 1977 b). Persistence of spores and toxins has been shown to be dependent upon such variables as temperature, pH, biotic competition, incident radiation and oxygen supply (NRCC, 1976).

Of particular concern is the possibility that B.t. may be selectively taken up by plants or animals after being released to the environment. Buckner et al. (1974) were able to detect viable B.t. spores in fresh water clams two days after spraying, but none were detected one month after spraying. With the Atlantic Region, investigators have monitored clams and oysters in estuaries which receive drainage from watersheds which were treated operationally with B.t. (var. kurstaki) (Smith et al., 1979). No viable B.t. was recovered during samplings up to three weeks after the spray event.

The extent to which B.t. may be adsorbed to or otherwise taken up by aquatic plants has not been investigated. Worthy of note in this respect is the fact that some terrestrial plants are known to contain volatile bactericidal substances which may affect B.t. persistence (NRCC, 1976).

The lack of environmental monitoring activity after operational B.t. programs in particular has severely limited the data base from which environmental impacts may be predicted. Such predictive capability is essential since B.t., because it is a biological agent, has potential problems not inherent in chemical pesticides. These include the ability to produce toxins, to multiply or persist within the environment and to mutate. In this regard it should be noted that it has been well established that under certain conditions B.t. is able to replicate quickly in the environment (Saleh et al., 1970; Sekijima et al., 1977); however, the possibility that B.t. (var. kurstaki) may mutate to a more pathogenic or toxic form or exchange genetic material with more pathogenic members of the same genus cannot be predicted with any degree of certainty (NRCC, 1976).

3.3.5 Chemical Insecticides

3.3.5.1 Chemical Analysis of Environmental Samples.

Procedures: Analytical techniques are available for the identification and quantification of the chemical pesticides most frequently used in Atlantic Region forest spray operations (fenitrothion, aminocarb). The parent compounds can be detected with current techniques in the commonly sampled environmental matrices of water, soil, sediment and tissue. Most of the regional laboratories involved in sample analysis associated with the New Brunswick forest spray operation use similar analytical procedures, although slight variations do exist.

Limited work has been attempted in the Atlantic Region on the analysis of pesticide metabolites. Methodologies are available to analyze compounds similar in structure to the various metabolites, so that in theory it should be possible to develop suitable analytical procedures. In fact, methodologies are available for many of the known or suspected metabolites of fenitrothion and aminocarb. However, isolation of these compounds has usually been done in conjunction with model ecosystems or in feeding studies where high concentrations of the parent pesticide compound have been used. There are few reports of successful routine identification of metabolites in environmental surveys done in conjunction with actual forest spray operations. Difficulties with isolation, cleanup and detection have not been overcome.

Reliability: Reliability refers to the degree of agreement of analytical results between different chemical laboratories.

The few quality control programs that have been carried out for the pesticides used in New Brunswick spray operations indicate that agreement between laboratories with established organic analytical capabilities is very good. However, it should be recognized that these programs have used spiked samples rather than actual environmental samples and the pesticide concentrations have been unrealistically high compared to environmental levels. Analytical techniques for detection and quantification of pesticides have become uniform over the past few years and results should be reliable for values significantly above the detection limits. Values close to the detection limit must be interpreted carefully since the deviation will undoubtedly be high in these cases. It also must be remembered that good agreement between laboratories only indicates a reliable and consistent procedure. Difficulties, such as poor but consistent recoveries from the matrix, may still exist. However, for the usual spray pesticides, a number of federal government laboratories in the Atlantic Region have developed methodologies which are reliable. Values obtained by laboratories which have not subjected their analytical methods to a competent external quality control program should be treated with caution. So little work has been done on the metabolites that no comment is possible on reliability.

Sensitivity of Analytical Techniques. At present, gas chromatography is the instrumental method of choice for measurement of the pesticides used in forest spray operations. Other methods such as gas chromatography/mass spectrometry (gc/ms) and high pressure liquid chromatography (hplc) have advantages in selectivity but detection limits remain approximately the same. Cost considerations have, so far, limited widespread replacement of gas chromatography by the relatively more selective techniques. Detection limits are adequate to detect instances where concentrations would present environmental and immediate human health concerns; however, long term environmental studies on the ultimate fate and/or residual concentrations of parent pesticides and metabolites require detection limits which most routine methods cannot attain. The problem lies not so much with the absolute detection capability of the instrumentation, but rather with the difficulty in limiting background interferences originating in environmental samples. Sophisticated work-up and isolation procedures or instrumentation with very specific selectivity (e.g., gc/ms) can result in a lowering of the detection limit of particular methodologies.

For metabolites, little regional information and experience are available. What is available often applies to model ecosystems where unrealistically high levels of parent compound have been used. It can be assumed that metabolite detection limits will be no better than those for the parent compounds and in fact, in most cases they will be worse.

Matrix	Approximate Range of Detection Limits*
Water	0.01 - 1 mg/L
Soil, Sediment	0.005 - 0.1 mg/g
Tissue	0.005 - 0.1 mg/g

* Parent compound (active ingredient) - aminocarb, fenitrothion.

3.3.5.2 Fenitrothion.

Fish: There have been several major reviews of the available literature concerning the toxicity of fenitrothion to fish (Anon, 1975; Kingsbury, 1976; Symons, 1977). The information contained in this literature, when compared with the concentrations of fenitrothion usually detected in streams and lakes receiving pesticide deposit during spray operations, suggests that fish mortality, as a direct result of the parent chemical fenitrothion entering the aquatic environment from operational forest sprays, is unlikely. There is, however, little information concerning the toxicity of various fenitrothion formulations, which are mixtures of the active ingredient and various adjuvants.

To try to fill these gaps the Environmental Protection Service has conducted bioassay tests on most of the components of fenitrothion formulations used in New Brunswick. The results of these investigations are presented in Table 3.9.

These results indicate that the fenitrothion/Arotex/water mixture is as acutely toxic as the pesticide fenitrothion alone, while the fenitrothion/Arotex/oil mixture has a somewhat higher LC50 and may be said to be less toxic than fenitrothion alone. Arotex 3470D is approximately as toxic as fenitrothion, while Atlox 3409F is considerably less toxic than fenitrothion alone. Fuel oil #2 and #4 and diluent oil 585 appear to contribute little to formulation toxicity, as evidenced by the high LC50 values obtained in bioassay tests.

Cyclosol 63, a diluent oil used for the first time in 1980, is considerably less toxic than fenitrothion alone, but is more than an order of magnitude more toxic than the other diluent oils. The fenitrothion/Cyclosol 63 mixture is approximately as toxic as fenitrothion alone. This represents a slightly greater than additive influence of the two components of that spray mixture.

TABLE 3.9 - ACUTE TOXICITY OF FENITROTHION AND ADJUVANTS TO RAINBOW TROUT (*Salmo gairdneri*) FINGERLINGS* AS DETERMINED BY EPS, HALIFAX

Material	LC50** (ppm)	Year Tested
Fenitrothion (A.I.)***	3.3 (1.8-5.6)	1976
Fenitrothion (A.I.) 14% Arotex 21% Oil (2:4) 65%	11 (5.6-18)	1976
Fenitrothion (A.I.) 33.3% Cyclosol 63 66.7%	4.2	1980
Arotex 3470D	3.8 (2.7; 5.0)	1976
Atlox 3409F	24-56	1976
Arotex-Atlox (1:1)	4.5 (3.0; 6.0)	1976
Fuel Oil (#2 and #4)	1000	1976
Diluent Oil 585	206	1978
Cyclosol 63	17	1980
Fenitrothion (A.I.)**** 88% Arotex 5% Atlox 5% Water 2%	2.4 (2.0; 2.8)	1976

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* All tests carried out under standard static bioassay conditions for 96 hours.

** Concentrations expressed are nominal.

*** A.I. - "active ingredient" or parent pesticide chemical.

**** Not used as spray mixture operationally. Intermediate in mixing process.

Use patterns display the disturbing trend towards the use of increasingly more toxic diluents. It is suggested that wherever possible, the least toxic diluent should be used in formulation, if chemical pesticides are to be used.

Fenitrothion is applied at 730 - 1460 ml/ha (10 to 20 U.S. fl. oz/ac) total formulation to emit 210 g/ha (3 oz/ac) active ingredient. Concentrations of active ingredient measured in natural water systems may be well below lethal levels to fish, but the potential amount of the formulation reaching the aquatic environment can be 3 to 7 times greater than the measured amount of active ingredient. Combined with possibilities of highly variable spray deposit and spray swath overlap, the possibility exists that concentrations of total formulation closer to the lethal thresholds for fish than previously predicted may be reaching the aquatic environment. In recent years, one fish kill has been documented as a result of an operational spray (Kingsbury, 1973) in the Atlantic Region.

Aquatic Invertebrates: Aquatic invertebrates, particularly benthic organisms, are highly sensitive to fenitrothion (NRCC, 1978). Table 3.10 lists some of the concentrations of fenitrothion acutely toxic to various aquatic invertebrates. The information in this table demonstrates that the concentrations of fenitrothion which are toxic to various aquatic invertebrate species span a considerable range (LC50s from 0.0006 ppm to 40.474 ppm in the table).

Of the aquatic insect species listed above, mosquitoes, stoneflies, caddisflies and mayflies appear to be the most sensitive (Coady, 1978; Eidt, 1975). Fenitrothion concentrations in aquatic systems after operational sprays of 210 g/ha fenitrothion are generally greater than those found to be toxic to the above species (Lord et al., 1978; Eidt and Sundaram, 1975; Coady, 1978). The ecological effects of mortalities of these and other aquatic invertebrates are dealt with in the next section of this document.

TABLE 3.10 - ACUTE TOXICITY OF FENITROTHION TO AQUATIC INVERTEBRATES

Species	Time (Hour)	LC50 (ppm)	Reference
Eriocera spinosa (diptera)	24	40.474	Symons, 1977
Aedes sp. (diptera)	24	0.0005-0.0045	Flannagan, 1973
Culex tarsalis (diptera)	24	0.0005	Symons, 1977
Daphnia pulex (cladocera)	24	0.045	Symons, 1977
Gammarus lacustris (amphipoda)	24	0.06	Flannagan, 1973
Acroneuria sp. (plecoptera)	24	0.002-0.006	Symons, 1977
Pycnospsyche sp. (trichoptera)	24	0.61	Wildish and Phillips, 1972
Ophiogomphus sp. (odonata)	24	0.066	Symons, 1977
Migronia serricornis (neuroptera)	24	0.186	Symons, 1977
Helix aspersa (mollusca)	Single Dose	175 μg/g	Rorke *et al.*, 1974
Purpura lapillus (mollusca)	48	3.5	Symons, 1977
Gibbula umbilicalis (mollusca)	48	10	Symons, 1977
Littorina littorea (mollusca)	48	16	Symons, 1977
Patella vulgata (mollusca)	48	3.6	Maggi, 1973

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TABLE 3.10 - (Continued)

Species	Time (Hour)	LC50 (ppm)	Reference
Artemia salina (crustacea)	48	1.9	Symons, 1977
Artemia salina (crustacea)	48	1.9	Symons, 1977
Clinabarus misanthropos (crustacea)	48	0.15	Symons, 1977
Carcinus maenas (crustacea)	48	0.01	Symons, 1977
Palaemonetes varians (crustacea)	48	0.0006	Symons, 1977
Crangon crangon (Crustacea)	48	0.003	Symons, 1977
Homarus americanus (crustacea)	48	0.012	McLeese, 1974
Penaeus aztecus (crustacea)	48	0.0025	Butler, 1964
Oronectes limosus (crustacea)	96	0.010-0.030	McLeese, 1976

Fresh water crayfish are moderately sensitive to fenitrothion and have toxic thresholds below the aquatic concentrations expected from operational sprays. Cage studies, however, have indicated that these organisms are able to withstand operational sprays of 175 g/ha fenitrothion (NRC, 1975).

There is very little information available on the composite and interactive toxic effects of various fenitrothion spray formulations on aquatic invertebrates in the environment or in laboratory situations. To gather some information on this matter, EPS conducted bioassays in 1980 with fenitrothion/Cyclosol 63 mixtures using Daphnia pulex as the test organism. A mixture of 33.3% technical fenitrothion and 66.7% Cyclosol 63 (the formulation used by J.D. Irving Ltd. in 1980) had a 48 hour LC50 of .032 ppm, while the Cyclosol 63 oil alone had a 48 hour LC50 of 13 ppm. The 24 hour LC50 for fenitrothion alone for Daphnia pulex is 0.045 ppm. This seems to indicate that the fenitrothion formulation is at least as toxic to Daphnia as is the active ingredient alone.

Commercially significant species such as lobster and shrimp have relatively low lethal thresholds. Salt water and estuarine concentrations of fenitrothion after spray operations have not been well documented in the Atlantic Region. Knowledge of the environmental effects of operational sprays on these organisms remains uncertain.

Molluscs are not particularly sensitive to fenitrothion, however, the ability of molluscs to accumulate the compound has been the subject of some research activity which is referred to later in this section.

Field Monitoring: The Environmental Protection Service in Newfoundland conducted a six week monitoring program in 1977 on two spray regimes to assess the immediate effects of pesticide application on two Newfoundland streams (Coady, 1978). Dramatic reductions in stream benthos were noted after the first application of fenitrothion at 210 g/ha. This reduction in benthos coincided with an enormous increase in invertebrate drift. Subsequent application in the same area of fenitrothion (210 g/ha) and aminocarb (90 g/ha) did not significantly affect invertebrate drift. Drift patterns and benthic populations did not return to normal levels over the six week monitoring period. In the second area chosen, aminocarb was applied twice at 90 g/ha. Increases in drift of aquatic invertebrates were observed after each application, but stream benthos was not significantly reduced and normal drift patterns were re-established in 24 to 36 hours after application of pesticides.

In 1978 two more streams were monitored for a six week period. Each area received the same amount of insecticide (Matacil 90 g/ha). In each area increases in aquatic drift occurred shortly after the spray and normal drift patterns were re-established within 24 hours. Benthic invertebrate populations were not significantly reduced.

Many small-scale field projects similar to the two conducted in Newfoundland have been conducted in New Brunswick since the change from DDT to less persistent chemicals such as fenitrothion. Attempts have been made to document the influence of fenitrothion on abundance and diversity of benthic invertebrates, by inference and by direct investigation, in order to identify the effects that changes in benthic invertebrate abundance and diversity may have on salmon and trout populations and production. Information resulting from studies of effects on stream benthos is varied. Following application of 560 g/ha fenitrothion, Penney and MacDonald (1968) reported that the number and weight of benthic insects was reduced to about 1/3 prespray amounts. At doses of 140, 210 and 280 g/ha some studies have indicated that fenitrothion did not significantly deplete the standing crop of benthic insects (MacDonald and Penney, 1969; Penney, 1970; Buckner and Serrazin, 1975; Eidt, 1975). However, other studies have reported temporary decreases in density of benthos after forest spraying with fenitrothion at similar doses (MacDonald and Penney, 1968; Dimond and Malcolm, 1971; Buckner _et al_., 1976; Coady, 1978).

The long term effects of fenitrothion spray programs on aquatic insects have not been thoroughly studied in New Brunswick. Few data exist to describe the decline and/or recovery of benthic insect populations subjected to successive or annual impact of forest spray chemicals. One study which did follow benthic insect populations for several years was conducted by EPS at Cove Stream, New Brunswick, from 1971 to 1977. The drainage basin was sprayed with fenitrothion each year from 1970 to 1973, initially at 210 g/ha and then for three years two applications at 140 g/ha. Fenitrothion was present in stream water after each spray application and in most cases it was not detectable four days after spray. Aquatic insect drift increased significantly following each pesticide application and benthic abundance was reduced following some fenitrothion sprays. The standing crop of benthic insects was substantially lower in each successive year of spraying. Data also suggest that benthic diversity was reduced after the fourth year of spraying. The benthic insect population increased to near original (1971) abundance two years after spraying ceased over the watershed.

There are, unfortunately, very few studies which report on the effect of annual spraying of fenitrothion which could support or refute the data from Cove Stream. One exception which supports our findings is a study by Elson et al. (1973) which indicated that after annual spraying of a stream with fenitrothion from 1969 to 1972 the aquatic insect population appeared to be depressed. Conversely, Eidt (1975) has indicated that the benthic populations of many streams in New Brunswick have survived a long history of insecticide treatment in spite of the apparent sensitivity of some taxa. However, he points out that there is no way of knowing what the composition of the benthic community would have been had there been no spraying.

Although there is limited and variable information with which to make judgements on the long-term impacts of forest pesticides on stream bottom fauna, there are substantial information and experience, as well as consistency of results, for the short-term impacts.

The following are generally acknowledged short-term effects of fenitrothion on benthic insect populations in streams:

1. Fenitrothion entering streams disrupts the normal diurnal pattern of downstream drift of benthic insects. Catastrophic drift generally results when fenitrothion concentrations reach detectable amounts (parts per billion).

2. Most of the insects in the increased drift are dead. Normally a small percentage of the diurnal drift is composed of dead organisms.

3. Disruption of the pattern of diurnal drift in streams is a short-lived phenomenon and the total number of drifting organisms declines to the normal range within 24 hours of the decline of fenitrothion concentration to beneath the detectable level.

4. The percentage of dead organisms in the drift declines to the normal range within 24 hours of the decline of fenitrothion concentration to beneath the detectable level.

5. Although apparently catastrophic kills of drifting insects have been documented, consequences to standing crop of benthos are generally not considered serious.

Residues: Most research to date has indicated that fenitrothion residue concentrations in various aquatic compartments decrease rapidly with time (Lord *et al*., 1978; Wells *et al*., 1979; Coady, 1978; Kingsbury, 1977, 1978; Holmes, 1979; Symons, 1977; NRCC, 1975). According to theoretical calculations (Eidt and Sundaram, 1975) the maximum concentration of fenitrothion expected in a forest stream 15 cm deep after spraying 210 g/ha will be 25 ppb. Of course, calculations of this nature assume total and immediate dispersion and dilution of uniformly applied pesticides and do not take into account variabilities inherent in the spray method and the environment which can produce greater accumulation of spray components at particular sites. It is not surprising, therefore, that monitors have found fenitrothion concentrations in stream water of 40-50 ppb (Coady, 1978; Holmes, 1979; Hall et al., 1975), and levels as high as 700 ppb in lake water (Moody et al., 1978).

Maguire and Hale (EMOFICO, 1980) have determined that fenitrothion which is truly dissolved in water volatilizes very slowly, with a half-life (due to the volatilization) of about 60 days. They have also determined, however, that the volatilization of fenitrothion from surface slicks of the formulated material is very rapid. In an experiment approximately 60% of the fenitrothion sprayed on the surface of the water volatilized at such a rate that the half-life was 18 minutes. This finding seems to indicate that a major route for fenitrothion disappearance, once it reaches the water, is through volatilization.

Hydrolysis of fenitrothion to form 3-methyl-4-nitrophenol is dependent on pH and temperature (rate increases with increasing pH and temperature). The pH at which fenitrothion hydrolyses rapidly, however, is very high (i.e., pH 12 - NRCC, 1975).

Zitko and Cunningham (1974) determined that fenitrothion is relatively stable in tap water (pH 7) for 45 days and Truchlik et al. (1972) determined that the chemical had a half-life of 150 days in purified water (pH 9.2, 20-21°C). Chemical degradation in natural waters, therefore, appears to be of minor importance in the case of fenitrothion.

According to the 1975 NRCC report, fenitrothion, when irradiated with ultraviolet light in various solutions, yields a number of products, including fenitrooxon, 3-methyl-4-nitrophenol, 3-carboxy-4-nitrophenol, carboxy fenitrothion and 5-methyl fenitrothion, with the main product being carboxy fenitrothion. The rate at which photodecomposition of fenitrothion occurs is for the most part unknown, however. One reference to rate data is that of Lockhart et al. (1973), who found that fenitrothion solutions placed in glass flasks and exposed to sunlight outdoors lost 95% of the parent compound within one day, while solutions in flasks wrapped in foil and exposed to the same conditions lost only 25% of the parent compound in eight days. Results of this nature are much less than definitive, however, as they do not account for factors such as photosynthetic activity, temperature differences and other environmental variables. Recent investigations by Maguire and Hale (EMOFICO, 1980) have detected significant amounts of p-nitro-m-cresol in pond water after operational sprays. Since the hydrolytic production of this compound proceeds at a slow rate, they presumed that the presence of this chemical is a result of photolysis.

The importance of photodecomposition in the disappearance of fenitrothion remains for the most part uncertain. It may prove to be a major pathway and further investigation of this mechanism is warranted.

Fenitrothion is rapidly adsorbed to suspended solids in aqueous systems (Zitko and Cunningham, 1974) and for this reason it is suspected that one of the sinks involved in the disappearance of fenitrothion from the water column is sedimentation. Fine sediments have been shown to adsorb more of the chemical than coarse sediments (Zitko and Cunningham, 1974).

It is somewhat surprising that monitoring efforts have consistently been unable to demonstrate significant concentrations of parent fenitrothion in sediments after operational sprays (Kingsbury, 1978; Anon, 1977; Wells et al., 1979). It has been speculated by Maguire and Hale (EMOFICO, 1980) that the lack of detection of parent compound in sediments may be due to rapid microbial reduction to amino fenitrothion, which is tightly bound to organic components of the sediment.

It is possible for micro-organisms such as bacteria to metabolize fenitrothion while it is suspended or dissolved within the water column, or within sediments. Bacteria, such as the soil bacterium *Bacillus subtilis*, have been shown to metabolize the parent compound readily to amino fenitrothion. Other soil and water bacteria (*Escherichia freundii*, *E. coli*, *Pseudomonas reptilivona* and *P. aeruginosa*) may also metabolize fenitrothion.

It has been shown that fenitrothion disappears much more rapidly from water which has a large microbial population than from purified water (Zitko and Cunningham, 1974). The above authors determined that the half-life for the parent compound in natural river water was 50 hours in enclosed aerated solutions. These authors concluded that microbial decomposition was probably the major route of fenitrothion disappearance in water. This conclusion was further corroborated by the work of Moody *et al*. (1978).

Animal and Plant Uptake: Recent work by Lakshminarayana (EMOFICO, 1980) has indicated that significant quantities (50 ppb) of parent fenitrothion are taken up by lake phytoplankton immediately after operational sprays of 210 g/ha. This represented a concentration factor of 2 and led the author to conclude that a potential for accumulation existed within the food chain, via this route. Moody *et al*. (1978) speculated that sediment partitioning of fenitrothion may, in fact, be due to uptake by epibenthic algae. Moody *et al*. (1978) also found that certain aquatic macrophytes, notably duckweed (*Lemma minor*) concentrated fenitrothion within the first 10 hours of spray to levels two orders of magnitude greater than the water concentration (2.19 ppm). These high concentrations declined rapidly, however, to .13 ppm within 23 hours. Another plant species, the hornwort (*Ceratophyllum demersum*), retained concentrations as high as .14 ppm for up to 192 hours.

The above results seem to indicate that aquatic plants may be a significant sink within the aquatic ecosystem.

Metabolites of fenitrothion have not as yet been identified from aquatic plants. They probably exist there, however, and when found should not differ significantly from those found in terrestrial plants; namely fenitro-oxon and S-methyl fenitrothion.

The uptake of fenitrothion by aquatic biota has received little research attention. Kingsbury (1978) found that caged brook trout (Salvelinus fontinalis) accumulated fenitrothion to a maximum of 0.2 μg/g within the first 12 hours of treatment of a lake with 140 g/ha. The accumulation coefficient (rate of uptake/rate of excretion) was approximately 400 and at 72 hours it had dropped to 84. This accumulation coefficient is somewhat higher than the value of 220 calculated by Takimoto and Miyamota (1976) for rainbow trout (Salmo gairdneri). Both values are relatively high, however, and demonstrate rapid uptake and slow excretion. Lockhart et al. (1973) determined even greater tissue concentrations of fenitrothion in rainbow trout experimentally exposed to 46 ppm fenitrothion for one day. Values of 1.17 ppm for liver, 1.6 ppm for kidney and 1.56 ppm for muscle were detected and indicate little significant partioning between these organs.

The primary metabolite of fenitrothion in fish, as in other animals, is thought to be fenitro-oxon, a much more potent cholinesterase inhibitor than fenitrothion itself (Zitko and Cunningham, 1974). Fenitro-oxon has been detected in much lower concentrations in fish tissue than fenitrothion. Kingsbury (1978) detected maximum concentrations of 66 ppb fenitro-oxon in fish six hours after spray. The metabolite was undetectable 72 hours later.

The only information presently available which relates to the uptake of fenitrothion by aquatic invertebrates other than molluscs is that of Lakshminarayana (EMOFICO, 1980) which indicates that zooplankton concentrations of fenitrothion peaked at 14 ppb when the water concentration was 26 ppb, indicating that fenitrothion was not concentrated above ambient levels. The lack of data on invertebrate uptake of fenitrothion is a significant gap since ingestion of aquatic insects by fish, for example, may be a significant route of pesticide contamination.

Fresh water and marine molluscs, because of their mode of feeding, have been shown to accumulate toxic substances, including organic pesticides. The possibility that chemicals used in the New Brunswick budworm spray program might be accumulating in shellfish prompted several small scale studies in recent years.

In 1976, EPS first measured fenitrothion in the soft tissue of oysters (*Crassostrea virginica*) and mussels (*Mytilus edulis*) taken from estuaries which received drainage from adjacent spray blocks. The samples collected 10 days post-spray revealed concentrations of fenitrothion ranging from 0.02 ppm to 0.66 ppm; levels which were considered high.

In 1977, EPS again sampled shellfish; however, in that year none of the estuaries where samples were collected were directly adjacent to spray blocks. Six areas were sampled, and all but one received drainage from distant spray blocks. Shellfish were analyzed for residues of fenitrothion, aminocarb, trichlorfon and phosphamidon. Of the 39 samples taken after spraying, a total of eight indicated concentrations of fenitrothion above detection limits, and a few had concentrations greater than .5 ppm. A similar study conducted by the Universite de Moncton in 1977 detected trace amounts of fenitrothion in three out of 13 shellfish samples (Mallet, 1977). Of 25 samples analyzed for aminocarb during the 1977 EPS study, two registered concentrations above detection limits. None of the shellfish samples analyzed for trichlorfon or phosphamidon showed concentrations above detection limits.

In 1978, EPS again undertook a survey of shellfish in fresh water and marine environments. This survey, while very limited (a total of seven shellfish samples were analyzed), detected no fenitrothion residues in the oysters sampled. Detectable levels of fenitrothion were also not observed at this time in mussles (*Anodonta* sp.) from a fresh water lake which received spray.

A more extensive survey was undertaken by V. Mallet at the Universite de Moncton (EMOFICO, 1980). Results from 94 analyses of clams (*Mya* sp.), mussels (*Mytilus edulis*) and oysters (*Crassostrea virginica*) from a range of sites varying from estuaries directly adjacent to spray blocks, distant areas indicate that fenitrothion contamination of shellfish was widespread. Half of the samples analyzed revealed concentrations above detection limits and some samples showed as much as 0.4 ppm. That study also detected contamination as far as 50 km from spray blocks. Several samples had detectable levels of fenitrothion degradation products (aminofenitrothion and s-methyl fenitrothion), but these may have been artifacts.

A recent laboratory study, conducted by the Department of Fisheries and Oceans (McLeese *et al*., 1979) on the uptake and excretion of fenitrothion in clams (*Mya arenaria*), mussels (*Mytilus edulis*), and fresh water clams (*Anodonta cataractae*), indicates that while these organisms can concentrate fenitrothion several orders of magnitude above ambient levels, relatively rapid excretion and low uptake ensure a low accumulation coefficient (uptake rate/excretion rate). The animals, therefore, depurate rapidly after exposure to fenitrothion.

Of course, the above study describes the accumulation of pesticide due to absorption through mucous membranes, as these animals probably ingested little food during the experiment. In the wild, animals would be accumulating chemicals through ingestion of contaminated food and particulate matter, as well as by absorption through mucous membranes.

To summarize the above results concerning shellfish residues, it appears that:

1. The potential exists for widespread trace fenitrothion contamination in shellfish from operational sprays.

2. Shellfish in areas as far as 50 km distant from sprayed areas can be contaminated.

3. Contamination of shellfish by fenitrothion is a transitory event.

The amounts of fenitrothion and other spray chemicals detected in shellfish are not directly lethal to the animals. What is unknown at this point is whether the spray chemicals are exerting any sublethal effects, such as decreasing breeding success or altering growth rates.

3.3.5.3 Aminocarb.

Fish: In 1976, bioassay work conducted by EPS, Halifax, indicated that Matacil 1.68 D had a 96 hour LC50 to rainbow trout fingerlings of 1 ppm, while the spray formulation used that year (Matacil 1.68 D - 6.2% and #2 fuel oil - 93.8%) had a slightly greater, though not significantly different, LC50 of 3 ppm. This represents a much greater than additive effect of the components of the formulation based on a 96 hour LC50 of 1000 ppm for the fuel oil diluent.

In 1978, Matacil 1.68 D was again tested by EPS. It was determined at this time that aging of test solutions outside and in the dark for 10 days reduced toxicity by an order of magnitude. Aminocarb measurements of these same solutions indicated that the concentration of active ingredient had remained almost unchanged. This was taken as evidence that the aminocarb content of the spray formulations was not the only, and in fact, not the major contributor to the acute lethal toxicity of the spray formulations.

Since that time, experiments conducted by the Department of Fisheries and Oceans (DFO), have indicated that the toxicity of Matacil 1.8 D (similar to Matacil 1.68 D) is primarily due to a so-called inert adjuvant nonylphenol. The formulation contains approximately 20% aminocarb, 50% nonylphenol and 30% oil extenders by volume. The Department of Fisheries and Oceans' experiments conducted on Atlantic salmon (Salmo salar) estimated that the lethal thresholds of aminocarb, Matacil 1.8 D, and nonylphenol are 8.7, 3.5 and .9 mg/L, respectively, for 96 hour exposure (McLeese et al., 1980).

Following this work, the Canadian Forestry Service at the Forest Pest Management Institute determined the 96 hour LC50 of nonylphenol to rainbow trout (Salmo gairdneri) under laboratory conditions to be .230 mg/L, and to brook trout (Salvelinus fontinalis) under field conditions to be .145 mg/L (Holmes and Kingsbury, 1980). Both of these numbers are lower than the results of DFO tests with Atlantic salmon.

EPS conducted nonylphenol bioassays on rainbow trout fingerlings in 1979 and determined that the 96 hour LC50 was .56 ppm. EPS has also recently conducted nonylphenol toxicity experiments on rainbow trout embryos in which the embryos, at late stages of development, were exposed to nonylphenol concentrations for 24 hours under static conditions in open dishes. The embryos were then transferred to clean water under flow-through conditions and mortalities were recorded up to 10 days post-hatch. These results indicate that hatching success was affected at exposure concentrations of about .5 ppm nonylphenol (Ernst et al., 1981).

A new aminocarb formulation, not presently registered for operational use, which does not contain nonylphenol (Matacil 180 F) has been observed to be much less toxic to aquatic organisms than the nonylphenol containing formulation (Matacil 1.8 D). Several authors (DOE et al., 1982; Szeto and Holmes, 1982) have determined that the Matacil 180 F formulation, which contains aminocarb as a particulate suspension, is approximately one tenth as lethal to rainbow trout as is the hydrocarbon soluble aminocarb (Matacil 1.8 D). If registered for forestry use, this formulation would probably provide a greater margin of safety for fish than the older Matacil 1.8 D formulation.

Aquatic Invertebrates: Aquatic invertebrates are, in some cases, more sensitive to Matacil and its components than are fish.

The Department of Fisheries and Oceans has determined that the marine shrimp (Crangon septemspinosa) is more sensitive to aminocarb than nonylphenol with 96 hour LC50s of .2 and .4 ppm, respectively (McLeese et al., 1980). The same authors determined the 96 hour LC50 for the lobster (Homarus americanus) to be 0.2 mg/L nonylphenol. EPS has recently conducted toxicity studies on the common water flea (Daphnia pulex) in which it was determined that the animals are immobilized after exposure of 48 hours to nonylphenol at concentrations as low as .14 ppm (Ernst et al., 1981). The technical aminocarb is even more toxic to water fleas (Daphnia magna) than nonylphenol. The 48 hour LC50 for this species was approximately 0.015 mg/L (Nelson, 1978 in NRCC, 1982).

Aquatic insects are comparatively sensitive to aminocarb. Woodward and Mauck (1980) observed a 96 hour LC50 for stonefly larvae (Pteronarcella badia) to range from 0.019 to 0.028 mg/L, and Eidt (1979) observed that under field conditions the Matacil 180 F formulation (which contains the particulate aminocarb) was toxic to mayfly nymphs (Baetis spp.) at concentrations less than 1 μg/L of aminocarb.

Mollusc species (Anodonta cataractae and Mya arenaria) are less vulnerable to low aminocarb and nonylphenol concentrations in the aquatic environment than are other aquatic organisms. McLeese et al. (1980 a) determined that the 360 hour LC50 for the soft-shelled clam (Mya anenaria) exposed to nonylphenol was 1.0 mg/L and 5.0 mg/L for the 585 solvent oil. The same authors observed that the 96 hour LC50 to the fresh water clam

(Anodonta cataractae) for nonylphenol was 5.0 mg/L and for total oil formulation was greater than 5.0 mg/L.

The results of a recent series of bioassays conducted on the fresh water clam (Anodonta sp.) and the salt water mussel (Mytilus edulis) indicate that both of these species are quite resistent to the lethal effects of the particulate aminocarb suspension Matacil 180 F (DOE et al., 1982). In these studies, the fresh water clam had a 96 hour LC50 of approximately 260 mg/L for both the oil and water field formulations* and the salt water mussel had 96 hour LC50s greater than 1000 mg/L for the two formulations.

The accumulation and excretion of the hydrocarbon soluble and particulate Matacil formulations, and their components, has been studied in regional laboratories (McLeese et al., 1980 b and DOE et al., 1982). These researchers have found that neither formulation is significantly accumulated by the salt water mussel.

Tables 3.11 and 3.12 summarize toxicity information concerning Matacil, aminocarb and adjuvant chemicals. Data are taken from a variety of sources, as noted in the tables.

Field Monitoring: The effects of operational Matacil use on aquatic invertebrates have been the subject of much less research effort than that which has been devoted to detecting similar effects from fenitrothion use.

* Water Formulation = 32.3% Matacil 180 F, 0.6% Atlox 3409 F, and 67.1% Water.

Oil Formulation = 26.3% Matacil 180 F, and 73.7% 585 Diluent Oil.

TABLE 3.11 - ACUTE TOXICITY OF AMINOCARB AND ADJUVANTS TO FISH

Material	Species	Test Duration	LC50 (ppm)	Reference
Matacil 1.68	*S. gairdneri*	96 hr	1 (.56-1.8)	Lord *et al*., 1978
Matacil 1.68 (6.2%)	-	-	-	-
Fuel Oil Diluent (97.8%)	*S. gairdneri*	96 hr	3 (1.8-5.6)	Lord *et al*., 1978
Matacil 1.68	*S. gairdneri*	96 hr	.86 (.750-.96)	Wells *et al*., 1979
Matacil 1.68 (aged 10 days in dark)	*S. gairdneri*	96 hr	<5.6	-
Matacil	*S. salar*	96 hr	3.5	McLeese *et al*., 1980 a
Aminocarb	*S. salar*	96 hr	8.7	McLeese *et al*., 1980 a
Nonyphenol	*S. salar*	96 hr	.9	McLeese *et al*., 1980 a
Nonylphenol	*S. gairdneri*	96 hr lab	.23	Holmes and Kingsbury, 1980
Nonylphenol	*S. fontinalis*	96 hr field	.145	Holmes and Kingsbury, 1980
Nonylphenol	*S. gairdneri*	96 hr	.56	Ernst *et al*., 1981
Nonylphenol	*S. gairdneri* embryos	24 hr	Hatching affected at .5 ppm	Ernst *et al*., 1981

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TABLE 3.11 - (Continued)

Material	Species	Test Duration	LC50 (ppm)	Reference
Matacil 180 F Concentrate	*S. gairdneri*	96 hr	122-175	DOE *et al.*, 1982
Matacil 180 F Oil Formulation*	*S. gairdneri*	96 hr	226-350	DOE *et al.*, 1982
Matacil 180 F Water Formulation**	*S. gairdneri*	96 hr	638-718	DOE *et al.*, 1982
585 Diluent Oil	*S. gairdneri*	96 hr	519	DOE *et al.*, 1982
Atlox	*S. gairdneri*	96 hr	53-748	DOE *et al.*, 1982
Sunspray 7 N Oil	*S. gairdneri*	96 hr	5600	DOE *et al.*, 1982

* Oil Formulation = 26.3% Matacil 180 F and 73.7% 585 Filuent Oil

** Water Formulation = 32.3% Matacil 180 F, 0.6% Atlox 3409-F, and 67.1% Water

TABLE 3.12 - ACUTE TOXICITY OF AMINOCARB AND ADJUVANTS TO AQUATIC ORGANISMS OTHER THAN FISH

Material	Species	Test Duration	LC50 (ppm)	Reference
Aminocarb	*Crangon* sp.	96 hr	.2	Zitko *et* *al*., 1979
Matacil 180 D	*Crangon* sp.	96 hr	.55	Zitko *et* *al*., 1979
Nonylphenol	*Crangon* sp.	96 hr	.4	Zitko *et* *al*., 1979
Nonylphenol	*Daphnia* *pulex*	96 hr	.14	Ernst, 1981
Aminocarb	*Anodonta* *cataractae*	96 hr	75.0	McLeese *et* *al*., 1980 a
Nonylphenol	*A*. *cataractae*	96 hr	5.0	McLeese *et* *al*., 1980 a
Matacil 180 D	*A*. *cataractae*	96 hr	<1.0	McLeese *et* *al*., 1980 a
Nonylphenol	*Homarus* *americanus*	96 hr	.2	Zitko *et* *al*., 1979
Aminocarb	*Pteronarcella* *badia*	96 hr	0.019-0.028	Woodward and Mauck, 1980
Matacil 180 F	*Baetis* spp.	N/A	<0.001	Eidt, 1979
Matacil 180 F Field Formulations	*Anodonta* sp.	96 hr	260	DOE *et* *al*., 1982
Matacil 180 F Field Formulations	*Mytilus* *edulis*	96 hr	>1000	DOE *et* *al*., 1982

The results of environmental monitoring activity (Lord, et al., 1978; Holmes and Kingsbury, 1980; EMOFICO, 1980) have been in general agreement that the concentrations of the active ingredient aminocarb, observed in aquatic systems after operational sprays, are approximately two orders of magnitude lower than those required to produce toxic effects in aquatic organisms.

Experimental sprays of nonylphenol, however, at rates simulating those that would occur if the maximum registered dose for Matacil 1.8 D were used (i.e., twice the normal single application rate), have resulted in aquatic residues which exceed those that have been determined to be toxic to aquatic organisms (Holmes and Kingsbury, 1980). In the above described study, it was found that one station in a stream which had received direct spray registered 1.1 ppm nonylphenol in the water at four hours post spray and another station registered .1 ppm at six hours post spray.

The above suggests that the safety margin is small for aquatic species when Matacil formulations which contain nonylphenol are sprayed to kill spruce budworm.

In the work that has been done on aquatic invertebrate response to Matacil applications, there is a great deal of variability in the results reported for various application rates.

At least one author (Holmes, 1979) has determined significant effects on certain mayfly nymphs at sequential application rates of 53 g/ha Matacil. However, other authors (Rabeni and Gibbs, 1976) have observed no detectable impact on stream insects at single doses of 170 g/ha Matacil.

The observations of a number of investigations are summarized in Table 3.13. Aquatic concentrations of aminocarb as high as 24 ppb have been noted after operational sprays of sequential 90 g/ha Matacil (Coady, 1978).

TABLE 3.13 - EFFECTS OBSERVED ON AQUATIC INVERTEBRATES AFTER OPERATIONAL APPLICATIONS OF AMINOCARB

Application Rate (grams as Matacil)	Effect Observed	Author
2 x 53 g/ha	Increased mayfly nymph drift. Decreased bottom mayfly nymphs.	Holmes, 1979
2 x 53 g/ha	No effect on overall insect populations.	Buckner and Sarrazin, 1975
2 x 70 g/ha	Increase in aquatic drift.	Anon, 1979
2 x 70 g/ha	No effect observed.	Buckner *et al.*, 1976 Anon, 1976 b
2 x 88 g/ha	No effect observed.	Penney, 1971
2 x 280 g/ha (fenitrothion) 1 x 70 g/ha	Increased drift of mayfly nymphs, stonefly nymphs, blackfly and midge larvae.	Kingsbury, 1978 b
2 x 90 g/ha	Decrease in lake surface insects (water striders and whirligig beetles).	Buckner *et al.*, 1975
1 x 105 g/ha	75% reduction in stonefly nymphs, 22% reduction in mayfly nymphs, 16% reduction in caddisfly larvae.	Penney, 1971
1 x 170 g/ha	No effect observed.	Rabeni and Gibbs, 1976
1 x 175 g/ha	Increased drift of mayfly nymphs, caddisfly larvae, blackfly larvae, chironomid larvae, riffle beetles. Decreased numbers of the above in bottom samples.	Holmes and Kingsbury, 1980

A recent study by Holmes and Kingsbury (1980) indicated a reduction in numbers of midge larvae found in Surber and rock samples and a significant increase in blackfly larvae drift after experimental application of an amount of nonylphenol simulating the maximum seasonal dose of Matacil. Therefore, some of the effects observed from Matacil application may arise from the nonylphenol component.

Briefly stated, it appears that the effects of Matacil on aquatic insects are highly variable and probably dependent upon stream characteristics, as well as application variations. Increased drift and decreased benthic populations of certain species seem to be a possibility, even at doses as low as 53 g/ha. The most sensitive insects appear to be mayflies, stoneflies, blackflies, caddisflies and midges.

Fate and Persistence: Knowledge of the behaviour and fate of aminocarb in aquatic systems is much less thoroughly documented than that of fenitrothion.

Not much is known about the volatilization of aminocarb. According to Kuhr and Dorough (1976), the half-life of aminocarb due to volatilization from glass plates is approximately 1.6 hours.

Aminocarb is rapidly broken down upon exposure to light (Kuhr and Dorough, 1976). Addison et al. (1974) have determined that the major photodecomposition product when aminocarb is irradiated in solutions of ethanol and cyclohexane is 4-dimethylamino-3-methylphenol. The major photodecomposition product from foliage deposits was shown to be methylamino Matacil (4-methylamino-3-cresyl methyl carbamate) (Waggoner, 1978). No data are available concerning the photodecomposition products in aqueous solutions.

No research has been conducted which specifically identifies those micro-organisms responsible for metabolizing aminocarb. Several species of micro-organisms including Pseudomonas melophthora, Fusarium solani, Aspergillus terreus, and Geolladium roseum have been identified which metabolize methylcarbamates in general (Kaufman, 1974).

The major metabolites from soil/water interactions have been identified as 4-methylamino-3-methylphenol methyl carbamate (des-aminocarb) and aminocarb phenol.

According to Kuhr and Dorough (1976), the half-life of aminocarb in river water is approximately one week, presumably due to microbial decomposition and photodecomposition. Other authors (Edwards, 1977) have indicated a longer half-life of approximately two and one-half weeks.

Sundaram et al. (1976) found maximum aminocarb residues of 2.1 ppb in pond water and 2.6 ppb in stream water after application of 70 g/ha aminocarb. These results compare well with those of Holmes (1979) who found maximum levels of 3.3 ppb aminocarb in river water five hours after application of 53 g/ha. Levels decreased to close to the level of detection within 36 hours post spray. Holmes also observed at this time that aminocarb in lake water persisted longer than in streams and rivers, being approximately 1 to 2 ppb 48 hours after application. Results of an EPS survey (Julien et al., 1979) in which parent aminocarb was detected in lake water at concentrations of 2.4 ppb, 48 hours after spraying of 86 g/ha, compare favourably with the findings of Holmes. The half-life calculated by Holmes (1979) for the disappearance of the aminocarb was 4.4 days for pond water and 8.7 days for stream water.

Other investigators have found higher values for aminocarb residues in water after operational spray. Coady (1978) found maximum concentrations of 12 ppb and 24 ppb, respectively, following two applications of 90 g/ha aminocarb. Holmes and Kingsbury (1980) found concentrations of aminocarb as high as 24.2 ppb in river water after experimental sprays of the seasonal maximum dose of Matacil (175 g/ha). In both of the above cases, the parent insecticide disappeared rapidly with few traces evident beyond 15 to 20 hours of spray deposition.

Sediment Uptake: Two EPS surveys, one in 1977 (Anon, 1977) and one in 1978 (Julien *et al*., 1979) failed to detect parent aminocarb residues in either estuarine or lacustrine sediments after operational sprays. No metabolites have been looked for in sediments, however, and analyses of this nature may be more significant, given the rapid rate at which the parent compound disappears.

Animal and Plant Uptake: Holmes (1979), in the only known study concerning uptake of aminocarb, was unable to detect aminocarb residues in a number of different fish species after two sequential operational sprays of 53 g/ha aminocarb.

No investigations have been made in the Atlantic Region into the metabolism of aminocarb by aquatic animals. Hydrolysis has been identified as the predominant metabolic reaction in mammals (Kuhr and Dorough, 1976). According to these authors, aminocarb may be metabolized by mammals into as many as six products which contain the carbamate moiety. These products include (a) 4-methylamino-3-methylphenol N-methylcarbamate, (b) 4-dimethylamino-3-methylphenyl N-hydroxymethylcarbamate, and (c) 4-amino-3-methylphenyl N-methylcarbamate. The 4-amino and 4-methylamino compounds were found to be ten times more potent than the parent compound in terms of anticholinesterase activity.

3.4 SUMMARY AND RECOMMENDATIONS

Nova Scotia's forests have been subjected to a long history of exploitation resulting in significant changes in both the forest and the associated forest industry. The present day forest is of greatly altered species composition and structure (age classes, girth, height) and of reduced quality compared to the forest of 200 years ago. This is the result of past forestry practices, inadequate or undesired natural regeneration following fires and clearcutting, and large scale mortality resulting from insect epidemics.

Nova Scotia's original forests were an ecologically distinct mixture of hardwood and softwood components. The few remaining stands of old growth climax forests are endangered by forestry operations (and other disturbance) because of their unprotected status. Protection of the 35 forested sites identified by the International Biological Program would remove from commercial production less than half of one percent of the province's forested land.

Approximately 40,000 hectares are clearcut annually for pulpwood in Nova Scotia, with negligible use of alternative harvesting practices which facilitate natural regeneration. Roughly one-third of the clearcut areas do not regenerate naturally to commercially desirable species or are considered insufficiently stocked (i.e., too few trees). The remaining areas have frequently regenerated to over-stocked stands or to balsam fir, which has proven vulnerable to insect epidemics.

Clearcutting is particularly suited to harvesting in the boreal coniferous forest and, when conducted so as to encourage natural regeneration and provide wildlife habitat, few environmental impacts occur. For example, the use of riparian strips and small (25 hectare) clearcuts in such cases has been found complementary to multiple use. Clearcutting in hardwood or mixed forest, especially when carelessly done, has resulted in well-documented problems with regeneration and, in some cases, significant nutrient losses and erosion. In all cases, the degree or occurrence of an impact is governed by site conditions and operator skills.

The impacts which may be caused by clearcutting and forest road construction include: ground disturbance and erosion resulting in siltation of streams and possible loss of salmonid spawning and rearing habitat; temporary alterations in site hydrology resulting in increased stream flows; acid generation; and nutrient losses from leaching and accelerated decomposition of organic material on cutovers. The magnitude and duration of these impacts depend on site conditions and whether environmental guidelines were followed during road construction and harvesting. Impacts may be negligible after about five years on better quality sites; however, Nova Scotia's forested land is mainly of low to moderate productivity and many impacts may be of longer duration. CFS is now developing guidelines for projects carried out with federal funding that should identify and mitigate significant environmental concerns. The development of environmental regulations under the Nova Scotia Forest Improvements Act would also be desirable.

Expanded programs of intensive forest management (IFM) are now being implemented in an attempt to alleviate future wood supply problems through shorter rotations and increased yields per unit of land. IFM will generally involve extensive site treatments following clearcutting, including combinations of mechanical and chemical site preparation, planting with nursery-grown softwoods, and increased protection against insects, diseases, hardwood competition and fire. Due to costs associated with the above practices and the need to introduce better forest management, programs of IFM are subsidized by both federal and provincial governments. Less intensive practices such as regeneration cutting are also part of recommended forest management procedures and should be supported for implementation where practical.

Future impacts resulting from programs of IFM may include: reduced biological diversity resulting from the proliferation of softwood plantations; increased need for pesticide protection of plantations; localized acidification of soils and sensitive receiving waters resulting from the increase in pure softwood stands; altered capacity for wildlife production; possible contamination of watercourses with chemicals used for site preparation and stand protection; possible reductions in site productivity with subsequent poor stand development; and increased severity and duration of the more or less short-term ecological impacts which follow clearcutting. Several measures to reduce these impacts are suggested at the end of Section 3.2.7.

The arguments supporting clearcutting without regard to regeneration have generally been economic in nature, while those against clearcutting have generally been environmental. We believe that a detailed analysis of the economic and environmental costs of such unmodified clearcutting is overdue. If government subsidies and the total costs of reforestation are considered, other harvesting systems may be both cheaper and more environmentally benign in the long-term, especially in hardwood stands or mixed forest.

The application of pesticides for foliage protection or suppression of deciduous vegetation is the subject of concern to public and regulatory agencies alike. Pesticides reach the aquatic environment by direct application to surface waters, mobilization from the floor of ephemeral stream channels, overland flow, leaching, drift from nearby areas, and deposition with soil particles eroded from the land. In most forestry situations, direct application and drift are the prevalent routes of entry. While direct application to water can usually be controlled by conscientious spray operators, spray cloud drift presents more of a problem. The two components of spray clouds, droplets and vapour, are controlled by factors associated with the environment and by the characteristics of the spray formulation and delivery system. While the phenomenon of spray cloud drift is by no means well understood, research and experience have led to the establishment of guidelines which can reduce, but not eliminate, the degree of spray cloud drift. These include:

- increasing the size of the emitted droplets, which results in greater sedimentation rates;
- reducing the height to the safest possible in order to decrease the droplet fall distances;
- reducing the volatility of spray formulations by using only low volatility pesticides, and adding invert emulsions and emulsions to increase formulation thickness;
- spraying only under cool temperature and high relative humidity conditions;
- spraying only under conditions of moderate wind and avoiding stable atmospheric conditions; and
- decreasing aircraft speeds to reduce wing and rotor vortexing.

Buffer zones have been shown to reduce the deposit of pesticide in non-target areas such as water bodies. Unfortunately, the models which have been formulated to predict pesticide deposit are not accurate enough to provide a rigid definition of the width of the buffer zone required for all situations. Buffer zone requirements are dependent on a large number of variables and are usually best addressed on a site-specific basis.

Advice concerning buffer zones and other aspects of pesticide applications is provided to the Nova Scotia Department of the Environment through the Atlantic Region Pesticides Advisory Committee (ARPAC). This committee represents the concerns of both Environment Canada and Fisheries and Oceans Canada.

The chlorophenoxy herbicides 2,4-D and 2,4,5-T are the only pesticides registered and effective for conifer release and site preparation. Several other compounds such as glyphosate, fossamine ammonium, hexazinone and trichlopyr, show promise for these two purposes but are not presently registered.

Polychlorinated dibenzo-p-dioxins (PCDD) have been found as contaminants of both 2,4-D and 2,4,5-T. The most toxic dioxin isomer, 2,3,7,8-tetrachloro dibenzo-p-dioxin (TCDD) has been isolated only from 2,4,5-T, but other di-, tri-, and tetra-isomers have been found in both herbicides. The PCDD content of 2,4-D and 2,4,5-T is now regulated under the Pest Control Products Act, but it is possible that some of the toxic effects that have been attributed to phenoxy herbicides in the past were actually caused by PCDD contaminants.

The toxicity of phenoxy herbicides to fish depends on the specific formulation, the life stage of the organism and water quality characteristics. The ester formulations generally used in forestry are more acutely toxic to fish than are the less frequently used amine and acid formulations. The early life stages of fish are generally more sensitive than are adults. The toxicity of phenoxy herbicides to fish is greatly increased by decreasing water pH. This latter phenomenon is of special concern because of the regional tendency of surface waters to acidify due to acid rain and, on a more local scale, to the acidification of soils under conifer-dominated stands.

While generally less well studied than the lethal effects, several ~~of the~~ sublethal effects of phenoxy herbicides to fish have been observed. Effects demonstrated include reduced growth rates, and a variety of physical, behavioral, histological and biochemical abnormalities. The effects of most concern in vertebrate species, such as neurotoxicity, mutagenicity, carcinogenicity and immunosuppression, have not been observed in fish but have not been adequately investigated. Certain teratogenic and embryotoxic effects have been observed in some fish embryos exposed to high concentrations of the active ingredient or breakdown products of phenoxy herbicides.

It has been suggested that forestry herbicides have a great potential to cause changes at the ecosystem level due to effects on aquatic invertebrates or aquatic plants. Laboratory experiments and small scale testing have, indeed, documented a variety of ecological effects due to relatively large doses of herbicide. It is important to note, however, that such changes have not been documented following forestry herbiciding operations. Observations of the natural environment have not detected herbicide-induced changes that are large enough to exceed the normal temporal variations inherent in ecosystems.

Theoretical calculations indicate that normal forestry dosage rates can lead to concentrations of pesticides in water that are in the range where aquatic effects have been observed. It is dangerous, however, to extrapolate effects from laboratory experiments to the real environment on the basis of models which calculate pesticide residues in water following a spray. These models usually neglect the influence of environmental modifying factors. Models which predict residues following direct application also ignore physical factors such as adsorption which reduce the concentration of pesticide available to biota. We believe that theoretical calculations are not convincing evidence of an effect being likely.

The bulk of evidence available suggests phenoxy herbicides are not particularly persistent in the aquatic environment when compared to most chlorinated pesticides. Unfavorable environmental conditions such as low pH, low temperature and deoxygenated water will, however, slow down the rate at which these compounds are removed. Although biological uptake of phenoxy herbicides occurs, bioaccumulation does not appear to be a real concern in aquatic systems because 2,4-D and 2,4,5-T are rapidly metabolized and excreted by aquatic biota.

Most of the research effort into PCDD has gone into 2,3,7,8-TCDD, and this is virtually the only isomer which has been investigated in an aquatic context. Fish are extremely sensitive to poisoning by 2,3,7,8 TCDD, while invertebrates are somewhat less so. There is little published literature on the sublethal effects of PCDD on aquatic organisms, despite the importance of this area to species such as man.

The environmental fate and behavior of PCDD has not been well established. The half-life of 2,3,7,8-TCDD in aquatic sediments appears to be about one year under normal circumstances. Bioaccumulation has been observed. Unfortunately, limited effort has gone into monitoring residues of PCDD in environmental samples following the application of phenoxy herbicides.

Laboratory studies and extensive field observations indicate that the use of fenitrothion in the formulations applied to date will not result in direct fish toxicity. Aquatic invertebrates, on the other hand, are highly sensitive to the toxic effects of fenitrothion formulations and major disruptions of benthic community structure have been observed after operational use of the chemical. These disruptions are thought to persist for periods of up to a year after spraying. In this respect, it should be noted that, during the last few years, where fenitrothion operations have been conducted, increasingly more toxic diluents have been used in the operational formulation. This trend should be discouraged.

Fenitrothion does not appear to be particularly persistent in the aquatic environment. It is rapidly removed from the water column through processes such as adsorption and sedimentation. Its disappearance from aquatic systems is thought to be due primarily to biological decomposition. Bioconcentration of fenitrothion does not occur in most species, but certain aquatic plants may strongly concentrate it and shellfish have been observed to accumulate and then clear the pesticide shortly after operational sprays.

Parent aminocarb appears to have little potential to accumulate or persist in the environment, but the fate and behavior of aminocarb metabolites are poorly known. Of the two presently produced aminocarb formulations, Matacil 1.8 D and Matacil 180 F, the latter is to be preferred because it does not contain an adjuvant, nonylphenol, which is toxic to fish and aquatic invertebrates. Indeed, the toxicity of Matacil 1.8 D to fish is primarily due to nonylphenol, not to aminocarb. Matacil 180 F is a new formulation and is not presently registered.

Because of its nonylphenol content, the safety margin of Matacil 1.8 D applications is small with respect to aquatic vertebrates. If Matacil 180 F is registered for forestry use, this formulation would probably provide a greater margin of safety for fish and aquatic invertebrates.

We recommend that the Commission consider the following points in its deliberations:

(1) Immediate priority should be given to preserving the remaining forested sites recommended as reserves during the International Biological Program.

(2) While follow-up inspections are carried out after forestry treatments, little work has been done in Nova Scotia to formally examine non-pesticide related impacts. The environmental effects of a proportion of future forestry projects should be monitored and the results made available to resource managers.

(3) As hardwoods are beneficial to long term site productivity and provide wildlife habitat, the use of herbicides or mechanical techniques to reduce their proportion to below 10-15% stems would not be environmentally sound. This level may, in any case, be below the economically viable control limits for hardwood suppression in Nova Scotia.

(4) Control of emission sources which cause acid rain is necessary if impacts on the forest ecosystem are to be reduced. The most feasible approach in Nova Scotia is through the adoption of low sulphur coal as a fuel for provincial utilities. We believe that this practice should be encouraged.

(5) Some sites, such as those with thin or fine textured soils, or steep slopes, are particularly susceptible to damage by intensive site preparation techniques (e.g., deep plowing). Special caution must be exercised on these sites and the use of equipment which severely disturbs the soil should be avoided.

(6) Guidelines for the construction of forest roads have been accepted by both the federal and provincial governments. Guidelines are still required for other components of the forestry cycle, such as guidelines to permit evaluation of the need for suppression of broadleaf competition. Federal-provincial cooperation in the preparation of guidelines which include environmental considerations as part of a more general code of good practice should be further encouraged. In the interim, activities for which guidelines have not been established should be approached with care.

(7) The existing review mechanism for permit applications for pesticide use should be continued. In addition, consideration should be given to extending the coverage of the provincial permit system to include major ground applications of pesticides directly by the landowner.

(8) Monitoring of spray efficacy and non-target effects should always occur in association with major spray programs, and the proponent should accept responsibility for much of the monitoring.

(9) Regulatory agencies should be encouraged to monitor the effectiveness of buffer zones at mitigating non-target impacts from pesticide applications in an effort to refine procedures for minimizing the effects of drift.

(10) Although the short term environmental effects of commonly used forestry insecticides and herbicides are reasonably well known, it is recommended that a program be established to provide for long term monitoring and research into ecosystem effects.

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POOR

QUALITY

ORIGINAL